Machinery Lubrication

January - February 2012

How to Inspect a Gearbox

What to look for, the proper methods and the required equipment

INSIDE

Storing Grease to Avoid Bleed and Separation

The Advantages and Disadvantages of Biodegradable Lubricants

Using Odor as an Oil Analysis Tool

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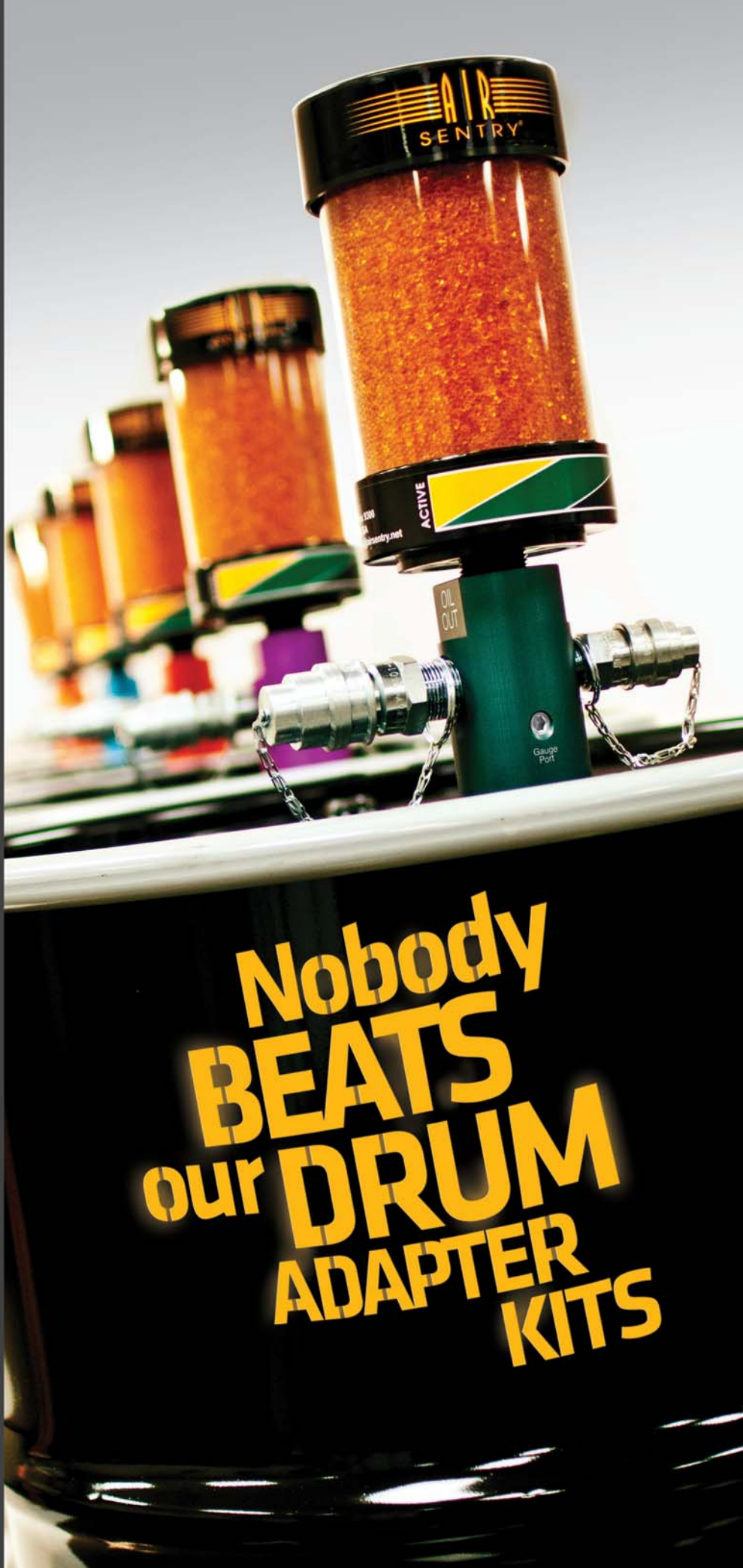

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AS I SEE IT

JIM FITCH NORIA CORPORATION

The BUSINESS CASE for LUBRICATION EXCELLENCE

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Machines fail for a reason. They're not supposed to wear out. Humans are at the root of the vast majority of these failures. It's also humans that can intervene and restore plants to healthy and sustained operation. This is not an imaginary concept but rather a living reality in a growing number of companies today.

Machine failure can deliver an important lesson on future prevention and remediation. Fortunately, there have been countless investigations into failure causes across wide-ranging machine types and applications. This learning has enabled organizations to greatly enhance reliability but only when machine and programmatic modifications were applied. Lubrication and reliability training programs are designed to teach this collective knowledge about failure prevention. Still, knowing is not the same thing as doing.

DOES IT MATTER?
(Prior to World-Class Lubrication Programs)

PROBLEM	# OF FINDS	% OF TOTAL
Lubrication	**542**	**53**
Bearing Defect	171	17
Belts	133	13
Base/Mounting	50	5
Resonance	37	3
Misalignment	31	3
Unbalance	19	2
Gear Defects	15	1.5
Coupling	9	1
Others	14	1.5
TOTAL	1,021	

Figure 1

54%
of lubrication professionals believe their company is doing an adequate job with lubrication, based on survey results from machinerylubrication.com

The Hard Currency of Lubrication-Enabled Reliability

Lubrication-enabled reliability (LER) relates to all activities that improve reliability through tactical changes in the use and application of lubricants. LER offers specific benefits and opportunities that don't exist with alternative reliability strategies. Yet, most companies seem to be in denial when it comes to lubrication. They see themselves as being lubrication responsible – a misguided belief that they are already doing an adequate job with lubrication. It's like healthy living through a proper diet. It's not a matter of just eating but rather the discipline of eating the right foods every single day.

The same applies to lubrication. It's not about blindly going through the same old tasks of lubricating your machines. This will not enhance reliability. Instead, LER is about reinventing how lubrication is done. This fact is learned from hundreds of published case studies on lubrication. It's very much like an untapped vane of gold that lies just below the surface. It's near at hand but difficult to see.

Fundamentally, LER has to be a business decision. Managers face wide-ranging opportunities when it comes to change and investment. Sound business judgment needs to be applied in deciding what to change next.

Conversely, the cost of repairing or replacing a failed machine (plus the associated lost production) is not a business decision that is carefully weighed against all options. It is outside of the control and judgment of management. The decision is driven entirely by the machine and its failure. The wisest thing managers can do at that point is to invest in a skillfully performed root cause analysis (RCA) followed by the prescribed changes needed to prevent reoccurrence.

LER is an initiative taken prior to failure, ideally when there is considerable remaining useful life. The following are three critical factors that should be considered in making reliability investments such as LER:

1. Find Untapped Opportunities That Yield Deep Benefits

The investment must have the potential to yield deep, rich benefits that outstrip the potential cost and risk. It can't be simply a mild chipping away at maintenance costs but rather a bona-fide homerun opportunity.

The magnitude of the opportunity is influenced by the current state of reliability

Lubrication-enabled reliability is about reinventing how lubrication is done.

(or unreliability). For instance, a company's approach may be just to continue reactive maintenance using the 4-R treatment — rapid component replacement, repair, removal or rebuild. In such cases, the opportunity is rich; the worse things are, the better the opportunity for change.

LER doesn't respond to failure but aspires to address the root cause. What is in constant contact with the machine that over time influences the rate of wear and corrosion? It is the lubricant. What, if changed, is best able to slow down that rate of wear and corrosion? Again, it's the lubricant. While there are other influencing factors, lubrication is the greatest common denominator.

As a case in point, see Figure 1. Fifty-three percent of all problems reported by this unnamed company were lubrication related. In addition, those that were not lubrication related (e.g., bearing defects, gear defects, unbalance, misalignment, etc.) would have been revealed by simply analyzing the lubricant (wear debris analysis).

Figure 2 is a plant-wide tabulation of the causes of mechanical failure reported by another company. The incorrect choice and usage of lubricants totaled 43 percent.

The Pareto Principle teaches us that the greatest yield from programmatic changes occurs when we focus on the 20 percent of the causes (critical few) that are responsible for 80 percent of the occurrences of failure.

2. Target Conditions that can be Changed and Controlled

Unarguably, there is much that's outside the realm of control for most reliability and

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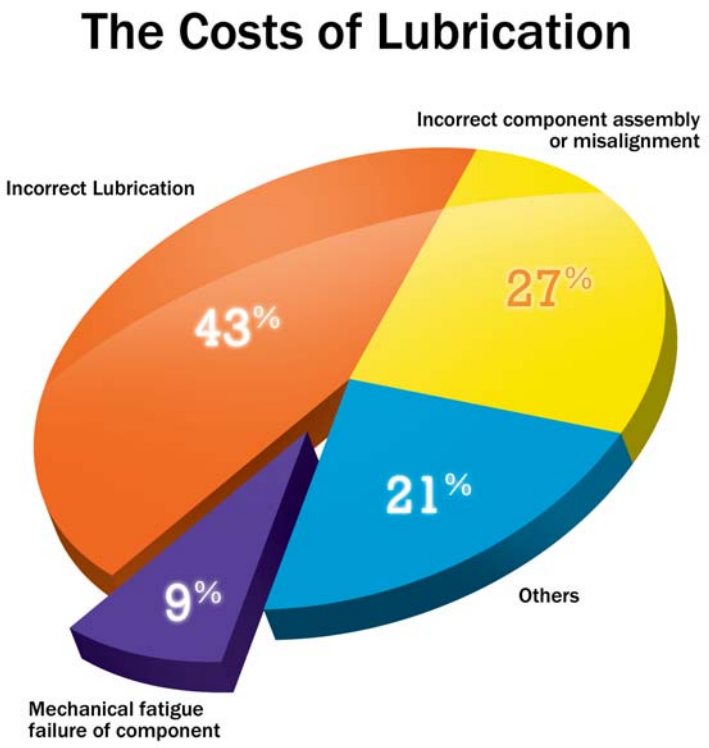


Figure 2

Ref. AIMAN (Italian Association of Maintenance Engineers) and IRI (International Research Institute) in conjunction with SKF

maintenance teams. For instance, we can't inherently know which bearings and gearboxes have design and manufacturing defects. However, we can control the quality of the job we do in mounting, fitting and installing machines/components. From that point forward, it's about wellness management – careful and continuous nurturing of machine health.

Fortunately, lubrication-enabled reliability is not high science. Any maintenance organization can accomplish it with proper training, planning and deployment. Much of it is behavior based and just good old common sense. It's about making modifications of people, machines, procedures, lubricants and metrics.

In the last issue of *Machinery Lubrication*, I introduced the concept of the Optimum Reference State (ORS). The ORS is a state of preparedness and condition readiness that enables lubrication excellence. It gives the machine and its work environment "reliability DNA" as it relates to lubrication. The enabling attributes of the ORS needed to achieve LER and lubrication excellence are:

- **People Preparedness.** People are trained to modern lubrication skill standards and have certified competencies.
- **Machine Preparedness.** Machines have the necessary design and accouterments for quality inspection, lubrication, contamination control, oil sampling, etc.
- **Precision Lubricants.** Lubricants are correctly selected across key physical, chemical and performance properties, including base oil, viscosity, additives, film strength, oxidation stability, etc.
- **Precision Lubrication.** Lubrication procedures, frequencies, amounts, locations, etc., are precisely designed to achieve the reliability objectives.
- **Oil Analysis.** This includes optimal selection of the oil analysis lab, test slate, sampling frequency, alarm limits, troubleshooting rationale, etc.

These ORS attributes are simple, fundamental changes that are within a plant's ability to modify and manage. They are definable, measurable, verifiable and controllable.

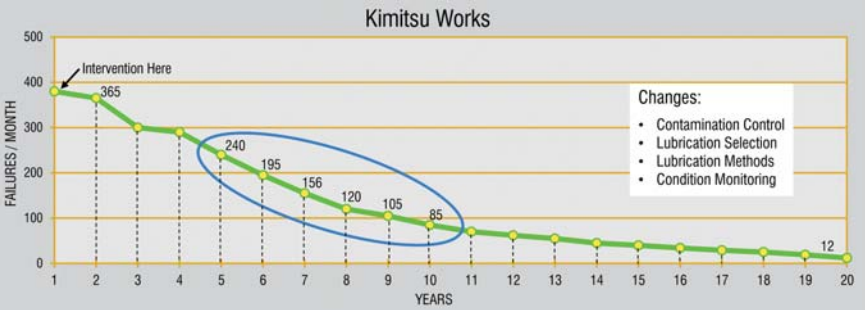
3. Choose Strategies that Offer Low, Manageable Risks

Stop fixing the machine and start fixing what causes the failure. This is proactive maintenance. Of course, it is hard to invest in something that is not yet broken. People are quick to respond to crisis but procrastinate to make changes when plants seem to be running reliably. Lifestyle changes sometimes require the jolt presented by a good health scare. Crisis puts focus on reliability. Change by aspiration alone is far more rare.

So what's the worst that can happen? Clean, dry and cool lubricants don't induce machine failure. The real risk is not in

Case Study: Nippon Steel

Nippon Steel, which is a past recipient of the Total Productive Maintenance Excellence Award, was the focus of a widely published case study on the benefits gained from lubrication excellence. The company implemented lubrication changes toward achieving the ORS and realized amazing benefits over a period of years in just one area of its plant. Bearing failures dropped from nearly 400 per month to just 12.



miscalculating the benefits from LER but rather in a botched or incomplete deployment. We've seen many examples of this in the past, and sadly it is a common outcome by those who have pursued LER. This can be the result of:

- Caving into pressure from old-timers who prefer business as usual
- Poor deployment (attempting to save money by cutting corners)
- Incomplete deployment and follow-through (getting halfway done and then becoming distracted by other initiatives)
- Lack of planning and preparation
- Lack of measurement and control (drifting back due to poor sustainability)
- Personnel changes (particularly the revolving door of leadership)

To de-risk implementation, you need leaders to champion the effort, good communication to stakeholders, adequate financial investment, and lots of monitoring and measurement (during and after deployment). Good implementation of LER follows along the lines of good project management. Be methodic and consistent. Rome was not built in a day. If you choose to take the do-it-yourself route, then start by getting the knowledge and help you need. You won't find world-class lubrication in your machine's service manual.

79% of lubrication professionals have learned lessons from a machine failure that have led to improved reliability, according to a recent survey at www.machinerylubrication.com

Closing the Knowing/Doing Gap

Sometimes you need an intervention. You can wait for a crisis to get things started, or you can start today. After all, you can't harvest the benefits of LER until sustained implementation is in place. Opportunity knocks today. Open the door.

About the Author

Jim Fitch has a wealth of "in the trenches" experience in lubrication, oil analysis, tribology and machinery failure investigations. Over the past two decades, he has presented hundreds of courses on these subjects. Jim has published more than 200 technical articles, papers and publications. He serves as a U.S. delegate to the ISO tribology and oil analysis working group. Since 2002, he has been director and board member of the International Council for Machinery Lubrication. He is the CEO and a co-founder of Noria Corporation. Contact Jim at jfitch@noria.com.

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FROM THE FIELD

JEREMY WRIGHT | NORIA CORPORATION

WHAT'S that SMELL? USING ODOR as an OIL ANALYSIS TOOL

Click to Read More From This Author

Field tests are some of the most overlooked, yet valuable tools that lubrication professionals can have in their arsenal. Most field tests are quick, inexpensive, simple to conduct and yield great information. One of my favorite field tests is odor.

Many characteristics and properties of an oil can be detected with our senses. We use our eyes to check level gauges, color, clarity, opacity, etc. We use our ears to determine conditions like cavitation, overloading, misalignments, etc. Why shouldn't we utilize our noses more often?

Smell is a very direct sense. In order for you to smell something, molecules from that something must find their way to your nose. Therefore, everything you smell is releasing molecules. These molecules are mostly small, light, volatile chemicals that find their way into your nasal passages. Once in the nasal passages, these molecules come in contact with a special patch of neurons. These neurons have very small, hair-like projections called cilia that increase the surface area to capture more of the molecules. The molecules attach to the cilia and trigger the neurons to send a signal to your brain, which causes you to perceive a particular smell.

So which oil odors should you be trying to distinguish? Here are a few you should be able to recognize.

Oxidation

Oxidation has a sour or pungent odor, similar to rotten eggs. It occurs when the hydrocarbon constituents of lube oil combine chemically with oxygen. As with most chemical reactions, oil oxidation is accelerated by heat and pressure. It is no different than other commonly encountered oxidation reactions, such as rusting. Just like the effects that rusting and other corrosive processes have on metal substrates, oil oxidation results in a catastrophic and permanent chemical change to the base oil molecules. The net effect of prolonged oxidation is that the oil becomes acidic (chemically), causing corrosion, while an increase in viscosity occurs (physically).

Thermal Failure

Thermal failure has the smell of burned food. It typically occurs when the base oil comes in contact with hot surfaces within the oil-wetted path or due to a sudden and rapid increase in temperature associated with the adiabatic compression of entrained air bubbles in pumps, bearings and other pressurized lubrication environments. When this takes place, the layer of oil that comes in contact with the hot machine surface or compressed air bubble can change chemically.

84% of machinerylubrication.com visitors use smell as an oil analysis tool.

Bacteria

Bacteria can produce a road-kill smell or stench. Once established, bacterial colonies will clog control systems, quickly degrade oil quality and performance, and generate corrosive byproducts. If not detected early, the problem will manifest itself into expensive repairs, extended downtime and a significant expenditure of scarce resources.

Contaminants

Contaminants such as solvents, refrigerants, degreasers, hydrogen sulfide, gasoline, diesel, kerosene and process chemicals all have a distinct smell of their own.

Sulfur Compounds

Sulfur compounds have a skunk-like odor. The various oxides of sulfur and water, both of which are combustion byproducts, react together to form sulphuric acid. This acid is neutralized by the basic reserve in the oil's additive package (overbase detergent) and normally results in the formation of metallic sulfates.

Nitrogen Compounds

Nitrogen compounds have an almond-like scent. Nitration is another form of oxidation. It results from the reaction of oil

Making Sure You're Good to Go.

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Unplanned equipment downtime and the loss of productivity due to wrong oil choice, degraded, or contaminated oil reduces profits. As immediacy and up-time drive global industry today, there is continuing pressure on equipment owners and maintenance managers to ensure uninterrupted service. Companies must be able to obtain accurate and actionable information about oil condition in real time and on-site to make smart maintenance decisions quickly.

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components with nitrogen oxides (NO, NO_2 and N_2O_4), which are produced from the oxidation of atmospheric nitrogen during the combustion process. In addition to causing oil thickening, nitration products are major contributors to the buildup of varnish.

Esters and Ketones

Esters and ketones have a perfume (fruity) odor. Esters are produced when carboxylic acids are heated with alcohols in the presence of an acid catalyst. Their odor is due to their volatile nature, which is caused by their chemical composition and conformations.

More Than a Sniff Test

Even in laboratories these days, there are headspace instruments that are not actually analyzing what's in the oil but what is coming out of the oil. Gas chromatography (GC) is one of the most widely used techniques in modern analytical chemistry. In its basic form, GC is used to separate complex mixtures of different molecules based on their physical properties, such as polarity and boiling point. It is an ideal tool to analyze gas and liquid samples containing many hundreds or even thousands of different molecules, allowing the analyst to identify both the types of molecular species present and their concentrations. So if your oil has a unique odor, you may want to run a GC test to see what these odors might be.

Although it's not a cutting-edge science and there aren't any cool handheld devices (yet), smell should be an essential part of your oil analysis program. It's fast, cheap and easy. Very few things in the machinery reliability world offer all three of these attributes.

One of my favorite stories about using smell as a field test involved a client who sent me an oil analysis report that was very basic. It had the normal range of tests for an "economy" report. It showed an increasing viscosity, a darkening, the formation of some sludge and varnish, etc., all the telltale signs of an oxidative failure, yet the oil had not been in service very long.

Over the phone, I told the client to open the bottle and take a big whiff of it. I could tell by the awkward silence that he was making a face — you know the one you make when you think you've heard what someone has said but know it couldn't be right. He repeated my request with a bit of sarcasm in his voice, to which I replied, "Just do it." A few seconds later, I heard, "Wow! It smells like burnt oil!" That was our clue that the problem was thermal failure. ■

About the Author

Jeremy Wright is vice president of technical services for Noria Corporation. He serves as a senior technical consultant for Lubrication Process Design projects and as a senior instructor for Noria's Fundamentals of Machinery Lubrication and Advanced Machinery Lubrication training. He is a certified maintenance reliability professional through the Society for Maintenance and Reliability Professionals, and holds Machine Lubricant Analyst Level III and Machine Lubrication Technician Level II certifications through the International Council for Machinery Lubrication. Contact Jeremy at jwright@noria.com.

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How to Inspect a Gearbox

What to look for, the proper methods and the required equipment

By Robert Errichello and Jane Muller

Although a comprehensive on-site gearbox inspection is desirable in many situations, there may be constraints that limit the extent of the inspection such as cost, time, accessibility and qualified personnel.

Cost and shutdown time might be perceived as prohibitive by management, but catching a problem in its earliest stages can save time and money in the long run. While it may seem too difficult to do a comprehensive inspection, a simple visual inspection of gear contact patterns through an inspection port can prevent future catastrophic failures. If in-house inspection expertise is not available, an expert can be hired to perform the inspection and train personnel.

Overcoming constraints in order to allow an inspection can help to extend gearbox life and avoid catastrophic failure. This might save time, money, injury to personnel and damage to adjacent equipment.

This article describes the equipment and techniques necessary to perform an on-site gearbox inspection.

Getting Prepared

Before beginning an inspection, prepare an inspection form for documenting your observations. It should be designed for your specific application. Next, assemble the necessary equipment (see sidebar on page 14).

Good Housekeeping is Essential

There are several sources of gearbox contamination, including those that are built-in, internally generated, ingressed and added during maintenance. Many gearboxes operate in dirty environments. Therefore, good housekeeping methods should be used during inspections. Areas around inspection ports and other openings should be cleaned before they are opened. Inspectors should take care not to drop anything into the gearbox. Shirt pockets should be empty, and tools should be stored in a tool belt. Ports should never be left open during breaks and should be closed and secured after the inspection is complete.

Walkaround Visual Inspection

You should perform a thorough external examination before the gearbox inspection port is opened. Use an inspection form to record important data that would otherwise be lost once cleaning is completed. For example, before cleaning

the exterior of the gear housing, inspect it for signs of overheating, corrosion, contamination, oil leaks and damage. Measure the tightening torque of structural fasteners that carry significant loads such as torque arm bolts. Look for evidence of movement including cracked paint or fretting corrosion at structural interfaces. Note the condition of the fasteners and inspect load-bearing surfaces of components for fretting corrosion or other evidence of movement.

Detecting Overheating

The following are signs of overheating:

- Smoke from shafts, seals or breathers
- Discolored or burnt paint on housings
- Water sprayed on the housing or shafts evaporates quickly, boils or crackles
- Temper colors on unpainted surfaces
- Melted plastic components such as shipping plugs
- Low oil level in sight glass or on dipstick
- Dark oil in sight glass or on dipstick
- Foam in sight glass
- Water in sight glass or sludge on filter element (may indicate oil cooler failure)
- Metal chips on magnetic plugs, chip detectors or filters (may denote gear or bearing failure caused by overheating)

To help you detect overheating, use this checklist.

✓ Visually inspect the gearbox exterior for signs of overheating.

✓ Record temperatures from gearbox thermometers, thermocouples or resistance temperature detectors (RTDs).

✓ Measure oil sump temperature.

✓ For pressure-fed systems with an oil cooler, measure temperature at the gearbox oil inlet and outlet, as well as the cooler water inlet and outlet.

✓ Estimate gearbox housing and shaft temperatures using water spray.

✓ Survey the gearbox housing temperature by touching it with the palm of your hand and using temperature-sensitive paint, crayons and labels or a digital thermometer probe.

✓ Check the gearbox housing temperature using an infrared thermometer or infrared imaging camera.

✓ Analyze gearbox oil for signs of oxidation or thermal degradation using on-site and laboratory tests.

✓ Analyze gearbox oil using particle counters, spectrometric analysis and ferrography to detect wear debris.

✓ Inspect internal gearbox components through inspection ports for signs of overheating, misalignment, inadequate backlash, inadequate bearing endplay or oil oxidation.

✓ Measure gearbox sound and vibration and compare to allowable limits.

Methods for Inspecting a Gearbox

- Visual walkaround
- Visual inspection through inspection ports
- Borescope inspection
- Measure temperature
  - Thermometers
  - Resistance temperature detector (RTD) probes
  - Thermography
- Measure oil pressure
- Measure sound and vibration
- Inspect filter elements
- Inspect magnetic debris collectors
- On-site analysis of lubricant
- Laboratory analysis of lubricant
- Magnetic particle inspection of gears
- Dye penetrant inspection of gears
- Documenting gear condition
  - Written
  - Sketches
  - Photography
  - Contact patterns

Inspect the Breather

The breather should be located in a clean, non-pressurized area away from contaminants. It should include a filter and desiccant to prevent ingress of dust and water. Also, ensure that the breather is shielded from water during washdowns.

Check Shaft Seals

Look for oil leaks at the shaft seals. If there are signs of oil leakage, the seals are probably allowing ingression of dust and water. If the gearbox has labyrinth seals, it should have external seals such as V-rings to prevent contaminant ingression.

Inspect Structural Interfaces

Figure 1 shows cracked paint at an interface, which indicates there was movement. The 45-degree direction of the cracks suggests the component on the right moved downward relative to the component on the left.

Examine Through Inspection Ports

Examine the inspection port cover and determine whether all bolts are tight and the cover is properly sealed or if there is oil leakage. Only qualified personnel should be allowed to open inspection ports. In some cases it is necessary to secure the ports with padlocks to enforce security.

Clean the inspection port cover and the surrounding area. Remove the cover, being careful not to contaminate the gearbox interior. Count the bolts and store them in a separate container so

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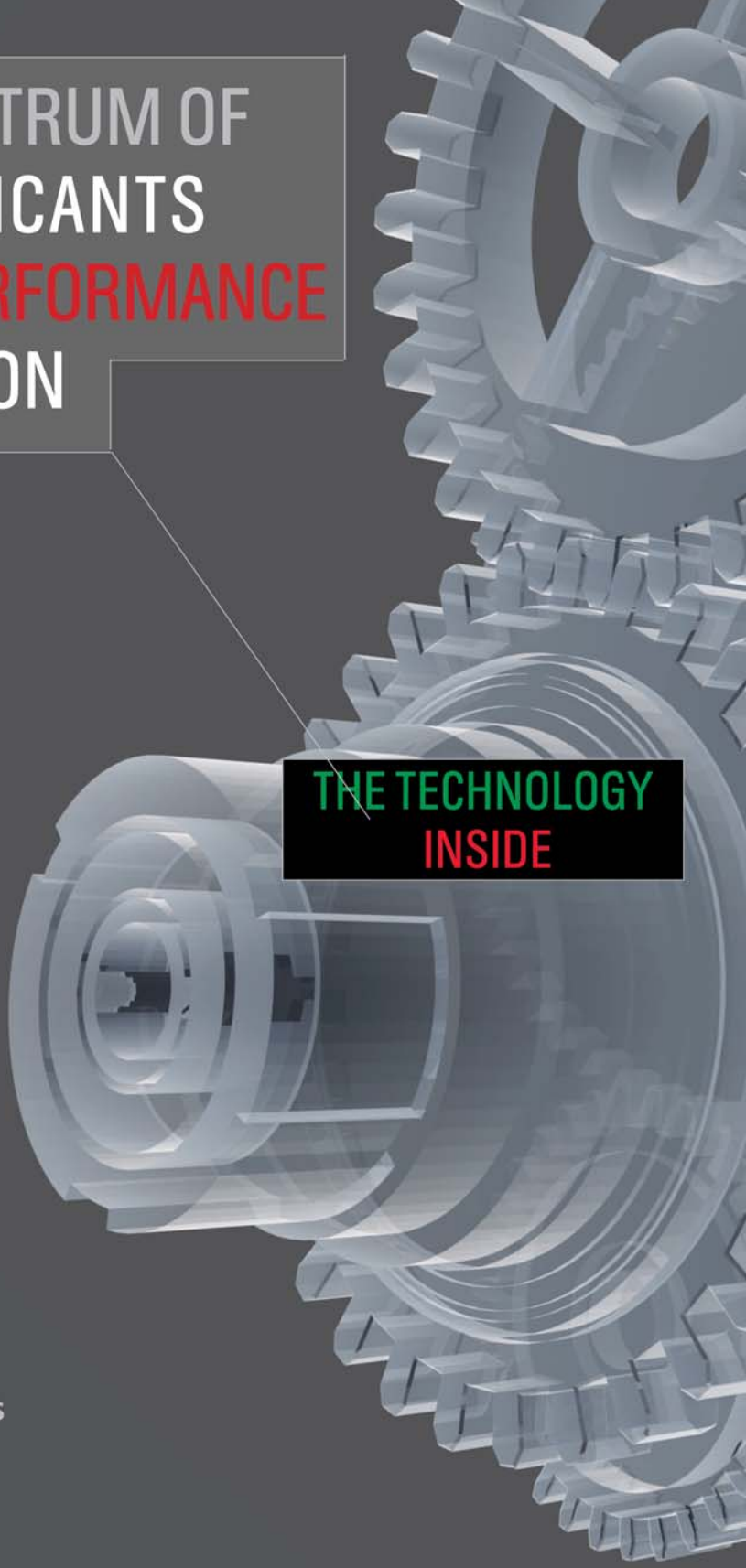

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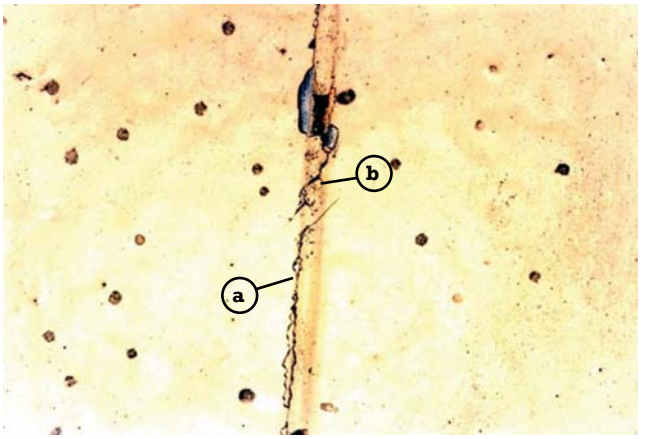
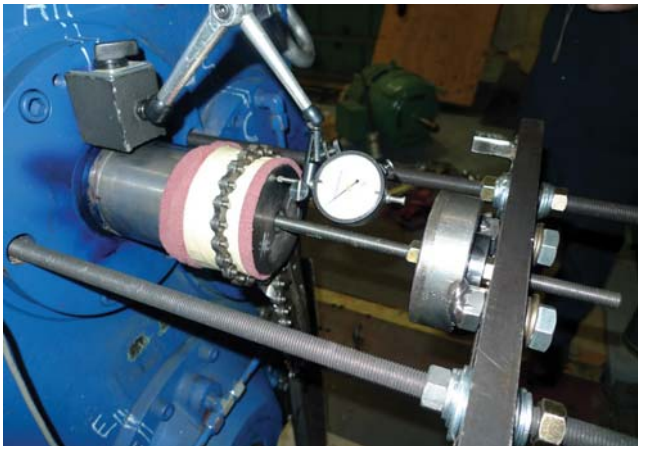


Figure 1. Cracked paint at the torque arm interface indicates movement (a). The 45-degree direction of the cracks (b) suggests the component on the right moved downward relative to the component on the left.



This fixture is used for measuring shaft endplay.

there is no chance they will fall into the gearbox. Observe the condition of the gears, shafts and bearings.

If the gears or bearings are damaged but still functional, management may decide to continue operation and monitor damage progression. In this case, the gear system should be continuously monitored. You should also make certain there are no risks to human life.

For critical applications, examine the gears with magnetic particle inspection to ensure there aren't any cracks that prevent safe, continued operation. If there are no cracks, you should periodically perform a visual inspection and measure temperature, sound and vibration.

Collect samples of the lubricant for analysis, examine the oil filter for wear debris and contaminants, and inspect magnetic plugs for wear debris.

The best place to take an oil sample from a gearbox is as close to the gearset as possible. Using a minimess sample port with tube extension will allow you to mount the sample port in the drain and manipulate the tube so that it terminates exactly where you want it.

The rule of thumb for installing sample port tube extensions is to keep the end of the tube at least 2 inches away from any static or dynamic surface.

You will need to flush the entire combination of tube extension, minimess sample port, sample port adapter and sample tube before you take your sample for analysis. Flush at least 10 times the volume of all the components prior to taking the sample for analysis. This typically works out to 3 or 4 ounces of fluid for a sample port with a tube extension of 12 inches.

To prevent further damage to the gears and bearings from wear debris, replace the filter element and then drain, flush and refill the reservoir with new lubricant. Continue to monitor

Equipment to Use for a Gearbox Inspection

- Toothbrush for contact patterns
- PT-650 Tooth Marking Grease for no-load contact patterns
- DYKEM layout lacquer for loaded contact patterns
- 6-inch medium mill bastard file for recording graphite contact tapes
- Drafting pencil with 2H lead for recording graphite contact tapes
- Swiss army knife with scissors for recording contact tapes
- Scotch No. 845 Book Tape for recording contact tapes
- 0.03 mm and 0.04 mm shims
- Felt-tip paint marker
- Ear plugs
- Sweatband
- Toolbelt
- Metric/inch tape measure
- Tweezers
- Spatula
- Telescoping magnet
- Leatherman "super tool"
- High-intensity LED flashlight
- Fiber-optic attachment for LED flashlight
- 6-inch metric/inch scale
- 3.5-inch magnifier
- 2-by-3.5-inch telescoping mirror
- 30X Panasonic Light Scope microscope
- Torque wrench
- Dial indicators with magnetic bases
- Inspection forms
- Lubricant sampling equipment
- Baggies and tags for specimens
- Micrometers
- Borescope
- DSLR camera with close-up flash
- Sound meter
- Vibration probe
- Digital thermometer
- Infrared thermometer or infrared imaging camera

lubricant properties during operation and repeat the maintenance if necessary.

If cracks are found or the damage is severe enough to warrant removal of the gearbox, measure shaft coupling endplay and alignment before removing the gearbox. Note the condition and loosening torque of fasteners including coupling and mounting bolts. To check for possible twist in the gear housing, install a dial indicator at each corner of the gearbox and then measure movement of the mounting feet as bolts are loosened. If there's no twist, each indicator will record the same vertical movement. If there is twist, calculate the twist from relative movements.

If no obvious damage is detected, document the condition of gears and bearings with photographs, sketches and written descriptions. Also, record gear tooth contact patterns for future reference (see Recording Gear Tooth Contact Patterns section).

Measure Gear Backlash and Shaft Endplay

Measure gear backlash by mounting a dial indicator so it is similar to a pinion tooth profile, block the gear to prevent its rotation and rock the pinion through the backlash.

To measure shaft endplay, mount a dial indicator at the end of a shaft and move the shaft in the axial direction. In most cases, this requires a fixture with a ball bearing on the central shaft that allows pushing and pulling the shaft while it is rotated to seat the bearing rollers.

Gear Mesh Alignment

Gears have maximum load capacity when the gear shafts are perfectly aligned and the transmitted load is uniformly distributed across the entire active face width. Unfortunately, many factors such as design issues, manufacturing accuracy, deflections, thermal distortion and external effects may combine to cause misalignment of the gear mesh. The result is that the gears are misaligned and the load distribution is not uniform.

Gear Tooth Contact Patterns

It is important to inspect gear tooth contact patterns because they can disclose gear mesh misalignment. The inspection should be done during commissioning of the gearbox to catch misalignment before it causes damage. Inspections should be regularly repeated to determine any changes in contact patterns caused by problems such as bearing failure.

What to Look for

Watch for heavy contact at the edges of the contact area, especially at each end of the pinion and gear face, at the tips of the teeth and along the roots of the teeth at the start of active profile (SAP). Determine if there are wear steps at the tooth ends, tips or the SAP. The pinion is often wider than the gear, and if there is misalignment, a wear step is likely to be at either end of the pinion. Severe misalignment usually causes macropitting.

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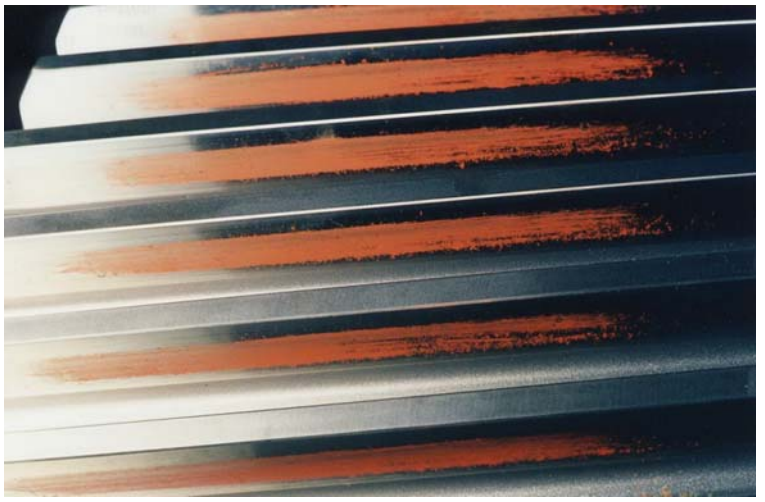
Severe misalignment can cause macropitting on helical pinion gears.



This image shows a no-load contact pattern transferred to an unpainted gear.

A different sector of the unpainted gear is revealed in this photo.

Recording Gear Tooth Contact Patterns

If there's evidence of gear misalignment such as macropitting concentrated at the ends of the teeth but no broken teeth or other failures that would prohibit rotating the gears, record the gear tooth contact patterns. The way gear teeth touch indicates how they are aligned. Tooth contact patterns can be recorded under loaded or unloaded conditions. No-load patterns aren't as reliable as loaded patterns for detecting misalignment because the marking compound is relatively thick. In addition, no-load tests don't include misalignment caused by load, speed or temperature. Therefore, if possible, follow any no-load tests with loaded tests.

Recording No-load Contact Patterns

For no-load tests, thoroughly clean and paint the teeth of one gear with a soft marking compound and then roll the teeth through the mesh so compound transfers to the unpainted gear. Turn the pinion by hand while applying a light load to the gear shaft by hand or a brake. Use clear tape to lift transferred patterns from the gear and mount the tape on white paper to form a permanent record.

The compound PT-650 Tooth Marking Grease from Products/Techniques Inc. works best. Scotch No. 845 Book Tape (2 inches wide) is preferred for lifting contact patterns.

Figure 2 shows contact tapes that indicate a contact pattern wandering from centered in some sectors of the gear to biased toward the left end of the face width in other sectors. This type of misalignment is caused by runout of the gear. It can only be corrected by replacing the gear with a more accurate one.

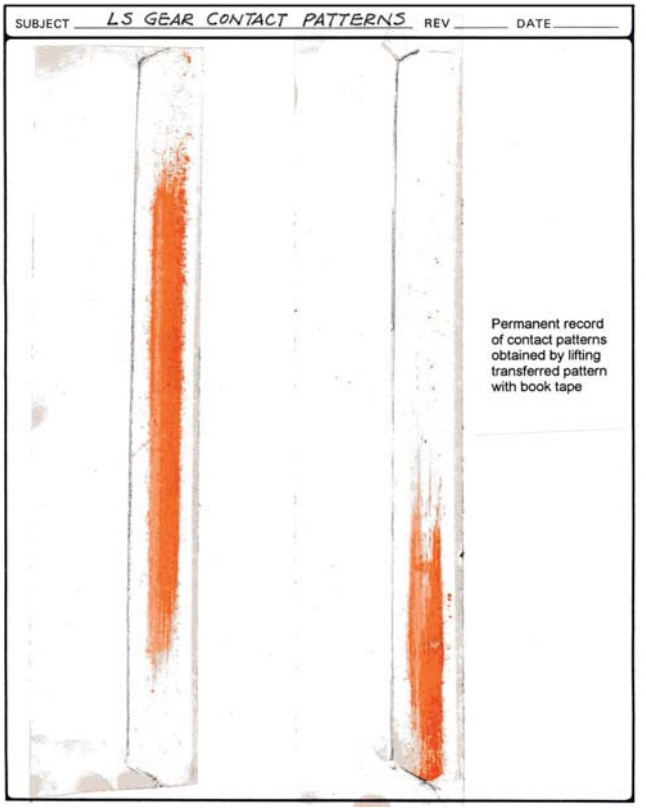

SUBJECT LS GEAR CONTACT PATTERNS REV DATE
Permanent record of contact patterns obtained by lifting transferred pattern with book tape

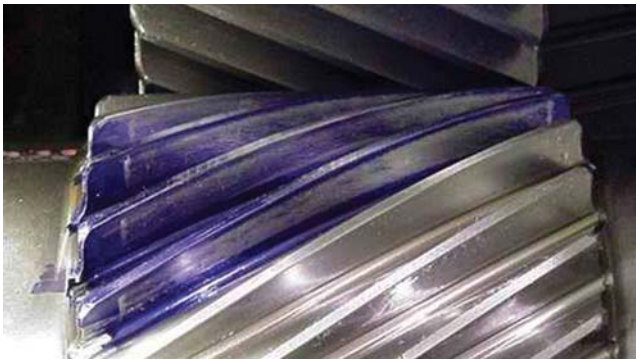
Figure 2. Documentation of no-load contact patterns.

Recording Loaded Contact Patterns

For loaded tests, thoroughly clean the teeth with a solvent and acetone. Paint several teeth on one or both gears with a thin coat of machinist's layout lacquer (DYKEM). Run the gears under load for sufficient time to wear off the lacquer and establish the contact pattern. Photograph the patterns to obtain a permanent record.

If possible, record loaded contact patterns under several loads, such as 25, 50, 75 and 100 percent of full load. Inspect the patterns after running about one hour at each load to monitor how the patterns change with load. Ideally, the patterns shouldn't vary with load. Optimum contact patterns cover nearly 100 percent of the active face of the gear teeth under full load, except at extremes along tooth tips, roots and ends, where contact should be lighter as evidenced by traces of lacquer.

Think of on-site gearbox inspections as preventative maintenance. Problems caught early and corrected can prevent catastrophic, costly and dangerous failures down the road.



This pattern was recorded at 50 percent load.

This pattern was recorded at 100 percent load.

SLIGHT CHANGES Can Mean BIG PROBLEMS

Copper readings can be particularly alarming when increases are in the hundreds of parts per million. However, huge increases are typically insignificant in terms of component wear. Ironically, small subtle increases in copper are of greater concern and should be examined closely. Copper alloy component wear is generally accompanied by lock-step increases in alloy metals such as lead, tin, aluminum and zinc. The amount of alloy metal present in brass/bronze components is only a small percentage of the total copper content. Changes in these alloys may be only a few parts per million but should be taken seriously when present with copper increases.

Controlling Contamination

Portable transfer/filter carts are versatile and can be used for more than just transferring fluids. Other possible uses include offline filtration, cleaning stored lubes, flushing after machine repair and rebuild, flushing during equipment commissioning and draining a reservoir or sump.

Greasing Gearbox Bearings

Does your gearbox have a sealed or open input shaft bearing? This bearing is often above the gearbox oil level and must be greased if it is an open bearing. Manufacturers may ship the gearbox with a plug where the grease fitting is needed to prevent damage during shipping.

In addition, the manufacturer may change the input shaft bearing design from open to sealed and back to open without notification. Small changes such as no longer receiving an attached plastic bag with a grease fitting included with the replacement gearbox may be a clue to a change in design.

Always check the manual included with the new gearbox to see if the lubrication needs have changed.

Advice for Coupling Grease Application

When changing the lubricating grease in a geared motor coupling, always apply a full coating of grease to the teeth of the coupling. Never fill the coupling housing completely with a grease gun due to expansion of the grease as the motor comes up to running temperature.

The "Lube Tips" section of *Machinery Lubrication* magazine features innovative ideas submitted by our readers. Additional tips can be found in our Lube-Tips e-mail newsletter. If you have a tip to share, e-mail it to us at editor@noria.com. To sign up for the Lube-Tips newsletter, visit www.machinerylubrication.com and click on the "Newsletters" link at the top.

This expansion of the grease will apply internal coupling pressure, pushing the motor shaft off magnetic center and onto the thrust surface of your bearing, causing bearings to overheat and leading to early bearing failure.

Even after hand-packing the coupling, the motor should be run up to operating temperature, then shut down and the grease plug removed to allow excess grease and pressure to be released.

Inspect Your Level Gauges

Routinely inspect the vent hole in column-type vented level gauges. In dirty environments, the vent hole can become easily plugged, causing an air lock in the gauge headspace. This will result in a false oil level (higher than reality) in the gauge. Many prefer dual-port gauges instead (unvented).

'Handy' Sampling Tip

During regular weekly or monthly oil sampling, use a tube of "handy wipes" to keep your hands cleaner while handling sample equipment. This practice may not show directly in the cleanliness of the samples, but it feels cleaner, looks very professional and sends a message about the importance of contamination control.

Keeping Hydraulics Healthy

Baffles are an important component in a hydraulic reservoir. They allow the fluid time to cool, deaerate and to settle out water and dirt. A good rule of thumb for residence time in a reservoir is three to five times the pump output. If the system is highly contaminated, residence time may be 10 times the gallons per minute of the pump.

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HYDRAULICS AT WORK

BRENDAN CASEY

CONSIDER the LIFETIME OPERATING COST of HYDRAULIC MACHINES

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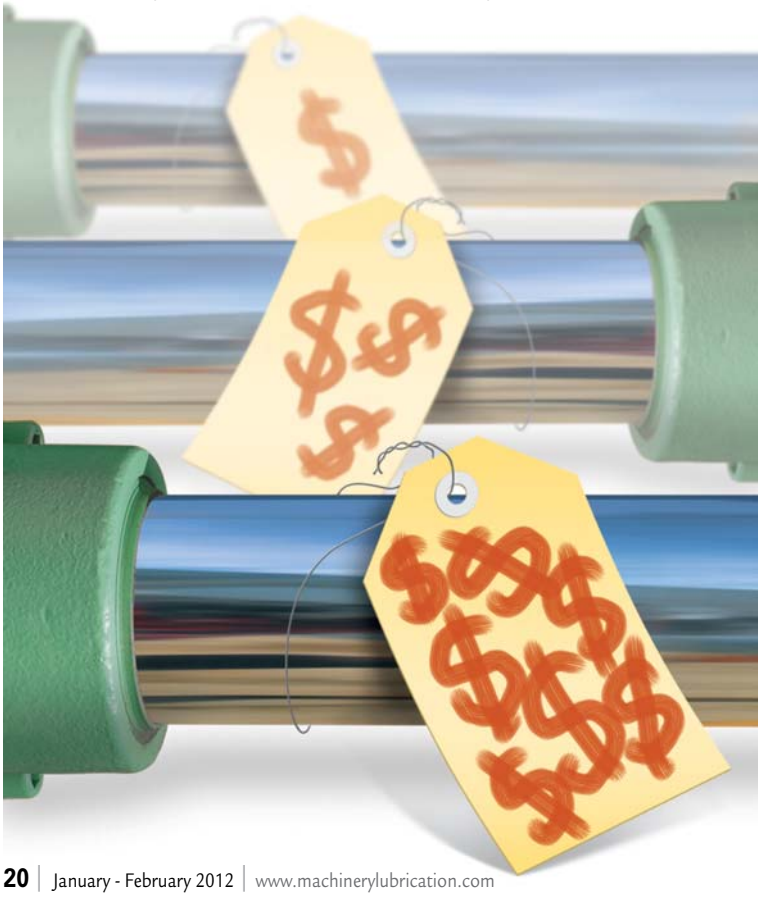
My son Benjamin turned 9 last month. For his birthday, we bought him a new mountain bike with all the bells and whistles: front shocks, rear mono-shock, front disc brake and 21-speed derailleur. I still can't get over the price. It was only $149, and that was the regular ticket price. Of course, it was made in China.

When you look at the finished product, you wonder how it could be so cheap. The retailer has his margin in there, and there's also shipping costs to consider. My guess is the ex-factory cost could be as little as $20 to $30.

While the bike looks like a top-quality product, only time will tell. But even if much did go wrong with it, for this sort of money, it would likely be cheaper to buy another one and cannibalize the original for spare parts. It is hard to argue with the economics.



As we all know, this is not just happening with bicycles. Whether we like it or not, China is currently the world's leader in low-cost manufacturing, which includes hydraulics.

It's just not realistic to pay a quarter or even half the price and expect the same performance or service life.

Hydraulic machines and most of their components are big-ticket items, so upfront savings are always seductive. But as I discuss in detail in *Insider Secrets to Hydraulics*, when considering a cheaper alternative, it's important to weigh what you will save if it lives up to expectations versus what it could cost you if it doesn't – and whether you're willing to carry the risk to find out.

This is another way of saying that the initial or upfront cost isn't necessarily the most important consideration. Instead, it's the life-of-ownership cost that counts the most. This involves thinking beyond the here and now. Superficially at least, the math is fairly simple. Just add the initial capital cost of the machine or component with the cost of keeping it running over the course of its useful life.

While the capital cost is easy to quantify, the lifetime operating cost is more difficult to calculate because it is usually dependent on the first variable.

Regular readers of this magazine are well aware of the importance of proactive maintenance and the influence it has on the life-of-ownership cost of any asset, including a hydraulic one. Of course, maintenance tasks consume time and resources, and therefore the need for maintenance should be designed out rather than designed in. However, this almost always means a higher initial investment, at which the majority of hydraulic equipment buyers baulk.

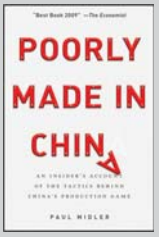
This is why we are likely to see Chinese hydraulic manufacturers make fairly rapid inroads into Western markets. Their entry strategy will be based on price, and a lower initial capital outlay will prove irresistible for a large number of potential owners. It's happening already. Most of us can probably think of an example.

But the Chinese are copiers, and they're not always good at it. Obviously, the quality of individual components affects the

reliability of the machine as a whole. For instance, if the entire machine was built in China, which factory did the machine's hydraulic filters come from? Did they come from a reputable filter manufacturer's facility in China or a "me-too" outfit? If from the latter, how well will they perform?

Also, where was the design of the hydraulic system borrowed? As pointed out previously, with most established equipment manufacturers in the Western world designing with one eye on initial capital cost and the other (blind) eye on reliability, the Chinese won't be taking the lead in this area anytime soon.

Beware of Quality Fade



In his book, *Poorly Made in China*, Paul Midler reveals that a common mode of operation for Chinese manufacturers is to bid low to get the business and then once production is under way substitute high-grade raw materials with low-grade alternatives. They do this to reshape the deal for maximum profit. Midler calls this "quality fade."

Imagine sourcing hydraulic hoses or seals from China. The quality is perfectly satisfactory in the beginning, but then "quality fade" creeps in. The results could be disastrous.

So by copying hydraulic designs that are less than ideal from a maintenance and reliability perspective, and then building these machines with components that may not be up to snuff, the learning curve for Chinese manufacturers and their customers could be long and at times painful.

As far as machines go, my son's new bicycle is about as unsophisticated as it gets. Provided the brakes don't fail and the wheels or handlebars don't snap off, its safe operation is not too much of a concern. Of course, I checked that everything was secure and correctly adjusted, and rode it around the block myself before I put him on it.

I'm sure my son will grow out of his new mountain bike long before he wears it out. But in the case of a Chinese-made hydraulic machine, if it's half the price of a locally made unit and lasts better than half as long without any safety incidents, the economics may be OK.

On the other hand, if it's half the price and only lasts a quarter as long, the economics don't stack up. So how do you know? The reality is that you don't. The same goes for Chinese-made hydraulic replacement parts or components. It's just not realistic to pay a quarter or even half the price and expect the same performance or service life.

78%

of lubrication professionals consider the lifetime operating cost of the equipment as the most important factor when purchasing a new machine or component, according to a recent survey at machinerylubrication.com

This is not to say that such economics can never be a good deal for the end user of the hydraulic equipment. It may indeed have a happy ending, but only if the user knows the devil he's dealing with, has considered the possible safety implications and has a large enough economic margin of safety built in. These are the only reasons why my son is riding around on a new mountain bike made in China. ■

About the Author

Brendan Casey is the founder of HydraulicSupermarket.com and the author of *Insider Secrets to Hydraulics, Preventing Hydraulic Failures, Hydraulics Made Easy* and *Advanced Hydraulic Control*. A fluid power specialist with an MBA, he has more than 20 years of experience in the design, maintenance and repair of mobile and industrial hydraulic equipment. Visit his Web site at www.HydraulicSupermarket.com.

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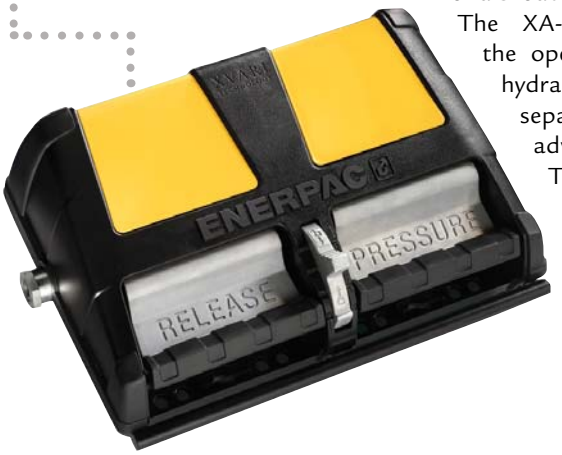

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PRACTICING OIL ANALYSIS

MATT SPURLOCK NORIA CORPORATION

USING CRITICALITY to DRIVE OIL ANALYSIS STRATEGY

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Oil analysis provides a huge payback when deployed through a proper strategy. While an extremely valuable tool in today's reliability programs, it is sometimes applied in an ad-hoc manner. This is a dangerous approach, as the program can quickly become quite costly due to overtesting or even show little value due to inadequate testing. Let's take a look at both situations.

Overtesting

A recently visited paper mill had a rather robust oil analysis program. This program was further optimized by the corporate reliability manager. The maintenance manager had a positive feeling about the benefits of predictive technologies and was supportive of the oil analysis program. While this was all seemingly positive data, the drawback was that the manager decided he wanted all equipment to be incorporated in the oil analysis program, including small centrifugal pumps containing less than even a quart of oil.

79% of Lube-Tips subscribers believe their plant's oil analysis testing is inadequate.

Taking this approach would have meant that the mill would run hundreds of oil samples on at least a quarterly basis. Adding to this, when following proper sampling procedures, we understand that the sampling hardware must first be flushed. When sampling small reservoirs, such as those in small centrifugal pumps, following the flush portion and then sampling, a complete oil change would have occurred on every pump each quarter. Considering the increased lubricant consumption coupled with the additional cost of testing the oil samples, you can see how the overall costs would add up quickly.

Although the maintenance manager should be commended for his aggressive drive toward equipment reliability, moving forward with the initially desired approach would have been costly, significantly reducing the program's overall return on investment (ROI).

Inadequate Testing

During a recent oil analysis program benchmarking exercise, it was asked how machines were selected for inclusion in the testing program. The initial response was, "We use criticality." When the process used for criticality assessment was investigated, it was revealed that there was no real process. The machines were selected based on what I like to call "perceived criticality." This resulted in a very small group of components initially being tested, although the program was growing in a methodical manner. When a machine component failed that was not part of the analysis program, the replacement component was then put on the program. So there was no real methodology at all.

This plant was experiencing a significant number of failures that could have been avoided had the program been put together properly in the first place. By taking this approach, the total cost of program development and optimization was incredibly high once the costs of missed opportunities were included into the equation.

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HY-PRO FILTRATION

A plant with a well-developed criticality system already has the foundation for establishing an equally well-developed oil analysis program.

Moving Forward

Oil analysis comes in three basic forms:

1) **Commercial Lab Testing** — Samples are collected and sent to a third-party laboratory for testing and analysis. This can take place on a routine basis or to confirm screening data from select on-site testing.

2) **On-site Testing** — Samples are collected and tested at the plant site using a number of potential on-site test equipment. Many advances have occurred in on-site test equipment that will be explored in a later issue of *Machinery Lubrication*.

3) **Online Testing** — Specialty meters (usually particle counters), moisture meters and dielectric testers are installed in a circulating system in order to capture "live" lubricant conditions. As with on-site testing equipment, this technology has grown significantly over the past 5 years.

Each of the basic types of oil analysis has an intended function and can offer significant benefit to the end user if deployed properly. For companies with a large number of lubricated components included in the oil analysis program, it is vital to incorporate some level of each of these categories for a well-rounded program.

Utilizing the criticality of machines that has been assigned through a documented method provides the best starting point in the decision-making process regarding which form, or combination of forms, is best for each component.

A plant with a well-developed criticality system already has the foundation for establishing an equally well-developed oil analysis program. Some of the primary decisions related to oil analysis that criticality can assist with include:

- Machine selection
- Reliability objectives
- Test slate selection
- Sample frequency

The days of the common test slate and frequency are over. The largest ROI will be achieved by using criticality to fine-tune an existing program and to get a new program off to an optimized starting point. The plant that does not have an established criticality assigned to machines should consider this foundational element. Without it, the entire predictive program is at risk of supplying less than the desired effect on overall reliability and ROI. ■

Understanding Operational Criticality

The oil analyst should know a machine's operational criticality. This can be broken down into two basic elements. The first is mission criticality, which considers the consequences of failure (production losses, safety, etc.) in relation to the machine's intended mission. The second is functional restoration, which basically asks in the event of failure, what would it cost to replace, repair and rebuild the broken machine.

These two elements of operational criticality don't always go hand-in-hand. Because of redundancy and standby equipment in some processes, an expensive repair may not always result in costly downtime. Likewise, in other cases, huge production losses may be triggered by small throw-away machine components.

Operational criticality is best defined by the asset owner, not by outside oil analysts or other non-stakeholders. For instance, consider using a scale from one to five for both mission criticality and functional restoration. A rating of one might mean failure is inconsequential, while a rating of five alerts that failure could have devastating consequences. The cost, frequency and quality of oil analysis will likely vary in accordance to how the machine is rated for operational criticality.

About the Author

Matt Spurlock is the director of oil analysis services and technologies for Noria Corporation. For the past 20 years, Matt has helped companies develop world-class lubrication and oil analysis programs. Contact Matt at mspurlock@noria.com and ask how Noria can help improve your lubrication program.

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IN THE TRENCHES

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JOSH PICKLE NORIA CORPORATION

The ADVANTAGES and DISADVANTAGES of BIODEGRADABLE LUBRICANTS

Vegetable oils can be used as lubricants in their natural forms. They have several advantages and disadvantages when considered for industrial and machinery lubrication. On the positive side, vegetable oils can have excellent lubricity, far superior to that of mineral oil. In fact, their lubricity is so potent that in some applications, such as tractor transmissions, friction materials must be added to reduce clutch slippage.

Vegetable oils also have a very high viscosity index (VI). For example, a VI of 223 is common for vegetable oil, compared to 90 to 100 for most mineral oils, about 126 for polyalphaolefin (PAO) and 150 for polyglycol. Viscosity index can be defined as a frequently used measure of a fluid's change of viscosity with temperature. The higher the viscosity index, the smaller the relative change in viscosity with temperature. In other words, oil with a high VI changes less with temperature than oil with a low VI.

Another important property of vegetable oils is their high flash points. Typically, this might be 326 degrees C (610 degrees F) for a vegetable oil, compared to a flash point of 200 degrees C (392 degrees F) for most mineral oils, 221 degrees C for polyalphaolefin (PAO) and 177 degrees C for polyglycol. Flash point can be defined as the temperature to which a combustible liquid must be heated to give off sufficient vapor to momentarily form a flammable mixture with air when a small flame is applied under specified conditions, according to ASTM D92.

More importantly, vegetable oils are biodegradable, generally less toxic, renewable and reduce dependency on imported petroleum oils.

62%

of lubrication professionals do not use any biodegradable lubricants at their plant, according to a recent survey at machinerylubrication.com

On the negative side, vegetable oils in their natural form lack sufficient oxidative stability for lubricant use. Low oxidative stability means the oil will oxidize rather quickly during use if untreated, becoming thick and polymerizing to a plastic-like consistency. Chemical modification of vegetable oils and/or the use of antioxidants can address this problem, but it will increase the cost. Chemical modification may involve partial hydrogenation of the vegetable oil and a shifting of its fatty acids.

The challenge with hydrogenation is determining at what point the process should cease. Depending on the required liquidity and pour point of the oil, optimum hydrogenation is established. Recent advances in biotechnology have led to the development of genetically enhanced oil seeds that are naturally stable and do not require chemical modification and/or use of antioxidants.

Did You Know? *Biodegradable oils currently make up less than 1 percent of all lubricants.*

Employing tests developed by the American Society for Testing and Materials (ASTM) and the Organization for Economic Cooperation and Development (OECD), oil is inoculated with bacteria and kept under controlled conditions for 28 days. The percentage of oxygen consumption or carbon-dioxide evolution is monitored to determine the degree of biodegradability. Most vegetable oils have shown to biodegrade more than 70 percent within that period, as compared to petroleum oils biodegrading at nearly 15 to 35 percent. For a test to be considered readily biodegradable, there must be more than 60-percent degradation in 28 days.

Similarly, by using a variety of tests involving fish, daphnia and other organisms, the toxicity of vegetable oils can be measured. In this case, both mineral oil and vegetable oil in their pure forms show little toxicity, but when additives are included, the toxicity increases.

Another disadvantage of using vegetable oils is their high pour point. Pour point is defined as the lowest temperature at which an oil or distillate fuel is observed to flow when cooled under conditions prescribed by test method ASTM D97. The pour point is 3 degrees C (5 degrees F) above the temperature at which the oil in a test vessel shows no movement when the container is held horizontally for 5 seconds. This problem also can be addressed by winterization, the addition of chemical additives (pour point suppressants) and/or blending with other fluids possessing lower pour points. Various synthetic oils can be used for this purpose.

If a high degree of biodegradability is required, then biodegradable synthetic esters are added to improve cold-temperature properties. On the other hand, if the goal is to maintain the so-called biobased property, where at least 51 percent of the lubricant is made of natural biomaterials, then a portion of the blend could be light mineral oil with low pour points. The latter will show a higher degree of toxicity and a lower degree of biodegradability.

TYPICAL TEST RESULTS FOR LUBRICANTS

LUBRICANT TYPE	PRIMARY BIODEGRADED QUANTITY
Vegetable Oils	70 - 100 %
Polyols and Diesters	55 - 100 %
White Oils	25 - 45 %
Mineral	15 - 35 %
PAG	10 - 20 %
PAO	5 - 30 %
Polyether	0 - 25 %

Why Use Biodegradable Lubricants?

Approximately 2.5 billion gallons of lubricants are sold annually in North America. Studies show that much of this fluid (60 percent) is not accounted for and ends up in ground water, rivers, lakes and on the ground itself, causing untold harm to the environment, fish and wildlife. Marine, forestry and agriculture industries in particular, along with citizen groups and governments, are becoming more and more concerned about our responsibility to the protection of the environment. The use of biodegradable fluids can help to maintain the environment and relieve some of the demand on mineral oils in the future.

About the Author

Josh Pickle is a technical consultant with Noria Corporation, focusing on machinery lubrication and maintenance in support of Noria's Lubrication Process Design (LPD). He is a mechanical engineer who holds a Machine Lubrication Technician (MLT) Level I certification through the International Council for Machinery Lubrication (ICML). Contact Josh at jpickle@noria.com.

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By Lawrence G. Ludwig Jr., Schaeffer Manufacturing

Storing Grease to Avoid Bleed and Separation

When storing grease and even during use, a certain amount of oil bleed will develop. Although it is common, the rate at which this bleeding occurs can be controlled through proper storage and usage techniques. Before looking at these strategies, it is important to understand the make-up of grease and the types of oil release that can take place.

Grease Composition

Grease = 70 to 95 percent base oil + 3 to 30 percent thickener system + 0 to 10 percent additives.

In general, a grease is a solid to semifluid product that consists of a dispersion of a thickening agent in a liquid lubricant. This thickener system can be made up of either simple or complex metal soaps of lithium, calcium, aluminum, barium or sodium, or non-soap such as clay (bentone) or polyurea. The thickener system can be thought of as a sponge that contains a matrix of fibers or platelets with a high surface area forming a dense network of micro-asperities (voids) or fibers. It is in these voids or fiber structure where the base oil and additives are stored until they are needed for lubrication.

Just like a sponge that releases water when it is squeezed, the grease releases its base oils from the thickener system when it is squeezed or stressed. The stresses a grease encounters can be generated either mechanically or thermally during application or storage.

In an application, a grease gradually releases oil into the working areas of the machine surfaces in order to lubricate them. The greater the amount of sheer stress encountered, the faster the grease's thickener system releases its hold on the base oils. The thickener system matrix imparts little or no lubricating characteristics. If the thickener system matrix did not release the base oils, the grease would be unable to perform its lubricating properties.

By the same token, a grease also should have the ability to exhibit some type of reversibility characteristics after the stresses are relaxed. Reversibility is defined as a grease's ability to recapture its base oils in order to return to its original consistency and continue functioning as intended. When a machine is shut off or when the conditions of mechanical or thermal stress are relaxed, the grease must have the ability to recapture its base oils to return to its original consistency. A grease's reversibility characteristics are dictated by the type and amount of thickener used. Generally, the higher the thickener content, the less the grease's reversibility.

Types of Oil Release

Although a grease's thickener system is not soluble in the base oil that it thickens, it does have an attraction to the base oil. Depending upon the amount of thickener system used in the grease's formulation, this attraction can be strong. The higher the proportion of thickener used, the greater its attraction to the base oil. As the base oil content is increased and the amount of thickener system is decreased, the forces of attraction also decrease, thus resulting in the base oil being loosely held in the thickener system matrix and easily separated.

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From these statements, you might think a higher thickener content is better. However, as mentioned previously, a thickener system matrix that does not release its base oils would be unable to perform its lubricating properties. Therefore, it is important for a grease to have the proper balance of base oil and thickener system content to function properly.

Oil release or separation from greases can be found in two distinct modes: static bleed and dynamic bleed. Static bleed is the release of the grease's base oil from the thickener system in the container in which it has been placed or in a non-moving part into which it has been introduced. Static bleed, which can also be referred to as oil puddling, occurs naturally for all types of greases and at a rate dependent on their composition.

Static oil bleeding can be affected by storage conditions, including the storage temperature, the length of storage, any vibrations the containers may be exposed to during transport or storage, an uneven grease surface in the container or the natural force of gravity. These factors can cause extremely weak stresses to be placed on the grease, resulting in the release of small amounts of base oil. Over time, a puddle of oil can form on top of the grease.

Static bleeding is more pronounced if the grease is soft in consistency (NLGI grades 00, 0 and 1) and/or if the grease's base oil viscosity is low (ISO 68 and lighter). It does not result in the grease being unsuitable for use.

Any base oil that has puddled or is lying on top of the grease can be either removed by decanting the free oil from the surface or by manually stirring it back into the grease. The quantity of oil that has separated from the grease is generally insignificant and represents a mere fraction of the total quantity of base oil that is held in the thickener system matrix. This small amount of oil will not adversely affect the consistency of the remaining product and will have little or no effect on the performance of the product.

Dynamic bleed is the actual controlled release of the base oils and additives during use due to temperature or mechanical stresses. It is important for the grease being used to have a controlled rate of bleeding in order for it to do its job properly.

Dynamic bleed conditions can also be caused or aggravated by the following conditions:

Overgreasing – Overgreasing can cause high temperatures, which result in oxidation of the grease and rapid separation of the base oils from the thickener due to churning.

Thermal Runaway – Too much grease in a bearing, mechanical conditions (misalignment, excess preload, etc.) and starvation can lead to higher running temperatures, which cause the base oils to be readily released from the thickener system matrix, leaving the thickener system behind to lubricate.

Cake Locks in an Overgreased Bearing – These cake locks can act as microscopic logjams. They are immobile and block flow paths and even mechanical motion of the bearing. When fresh grease is applied, the grease's base oils are separated and flow through the built-up thickener due to hydrostatic extrusion, leaving the thickener system behind. Additional build-up of this logjam can lead to elevated operating temperatures, resulting in increased bleeding of the base oils from the grease's thickener system.

Contamination – Gross contamination by dust, dirt, fly ash and dry powder contaminants can draw out the base oils from the thickener system over time, resulting in the thickening of the grease.

Mixing of Incompatible Thickener Systems – This accelerates de-gelling and oil separation.

Hydrostatic Extrusion – Grease subjected to constant pressure can separate by hydrostatic forces, just like water flowing through a sand filter. The base oils are literally squeezed from the thickener system.

Vibration and Centrifugal Forces – Prolonged vibration and/or centrifugal forces can cause grease separation.

A grease's oil bleed rate can be affected by a number of factors, including its composition, the type of manufacturing process used to produce the grease and distribute the thickener system within the base oil, and how the grease is stored once it reaches the customer. The ability of the grease to retain or release the oil depends upon all of these factors.

Without exhibiting some bleeding, whether static or dynamic, a grease will not provide lubrication for the application in which

Tests for Oil Bleeding

There are a number of different tests that can measure a grease's bleeding and oil separation characteristics. These tests can be categorized into two groups: static and dynamic bleed tests. The most common tests used to evaluate oil separation and bleeding are:

Static Tests

ASTM D-1742 Oil Separation from Lubricating Grease During Storage – This test predicts the tendency of a grease to separate oil during storage when stored at room temperature.

ASTM D-6184 Test Method for Oil Separation from Lubricating Grease (Conical Sieve Method) – This method determines the tendency of the oil in a lubricating grease to separate at elevated temperatures.

Dynamic Tests

U.S. Steel Pressure Oil Separation Test – This test is used to measure the oil separating and caking characteristics of a grease under fixed conditions that indicate the stability of a grease under high pressures and small clearances in a centralized grease pumping system.

ASTM D-4425 Oil Separation from Grease by Centrifuge – This method evaluates the oil separation tendency of a grease when subjected to high centrifugal forces.

Trabon Method 905A – This test is used to predict the tendency of a grease to separate oil while under pressure in a centralized lubrication system.

Although a grease may exhibit good resistance to oil bleed and separation in these static and dynamic tests, proper storage and handling of the grease are still key components to ensure that it is able to perform its job.

it is being used. The balance between these two modes of bleeding is the key to the grease's performance.

Storage and Handling Techniques

Like most materials, lubricating grease gradually will deteriorate with time. The rate and degree of deterioration depends on the storage and handling conditions to which the grease is exposed.

Grease may change its characteristics during storage. The product may oxidize, bleed, change in appearance, pick up contaminants or become firmer or softer. The amount of change varies with the length of storage, temperature and nature of the product.

Depending on the storage conditions, some greases can undergo age hardening, which results in the product becoming firmer and increasing in consistency or even softening. These changes in consistency can cause the grease to slip out of its original consistency grade. This behavior can be further aggravated by prolonged storage conditions. Because of this aspect, extended storage periods should be avoided.

If a grease is more than a year old, the National Lubricating Grease Institute (NLGI) recommends that it be inspected and the worked penetration tested to ensure that the grease is still within its intended NLGI grade.

Another recommended industry practice specifies that whenever any type of lubricant is received, the usage and storage methods must follow the first-in/first-out inventory system. This simply requires the user of the lubricating grease to use the grease that was put into the storage system first. In addition, grease manufacturers place a date code or bath number on the individual packages or cartons that can help determine the month, day and year the grease was made.

As previously mentioned, greases tend to bleed and release their base oils during storage. The rate of oil released from the grease will increase with time and vary based on the temperature at which it is stored. Ideally, grease should be stored in a cool, dry indoor area that does not exceed 86 degrees F (30 degrees C) and remains above 32 degrees F (0 degrees C).

It is not unusual to find grease containers in storage areas that have temperatures as high as 130 degrees F (54 degrees C). These storage areas also can be exposed to contaminants such as dust, dirt, moisture or rainwater, which can severely deteriorate the quality of the grease.

A grease container should never be exposed to direct sunlight or be stored in an area directly near a heat source such as a steam pipe, furnace, cab of a truck in hot weather, etc. This will only aggravate the rate of oil release that can occur.

Always store grease in its original packaging and keep the container closed until it is time for it to be used. Wipe the lid or cover of the container before opening and always use clean

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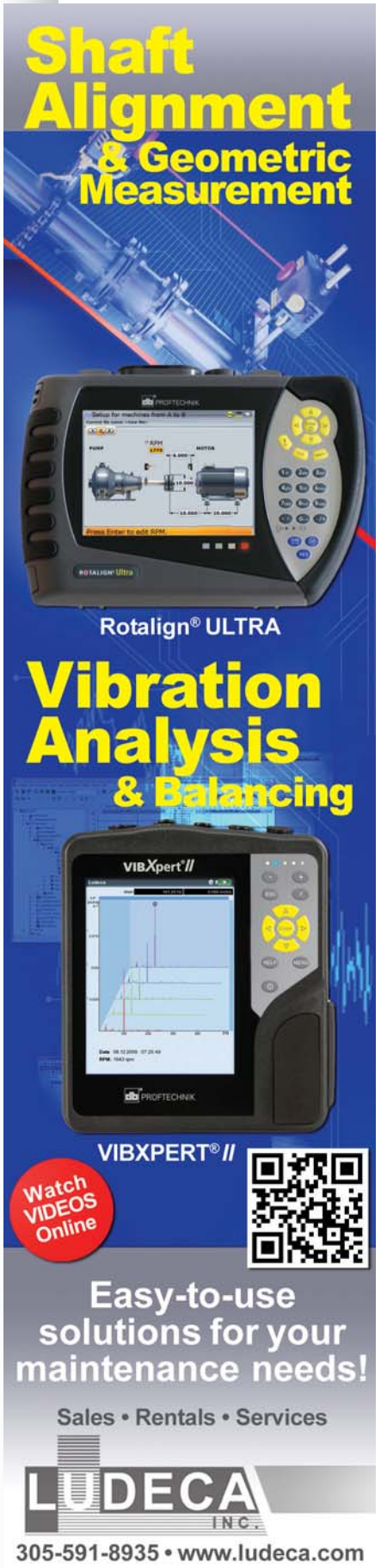

tools and dispensing equipment when handling or pumping the grease. After use, the container should be closed immediately and kept closed. Before placing the lid back onto the container, wipe off any dust, dirt or excess grease that may have accumulated.

Cartridge tubes of grease should be stored upright at all times. If a cartridge tube is left in a grease gun, the grease gun should be depressurized, wiped with a clean cloth to remove any contaminants and stored in a horizontal position inside a clean, cool, dry area to keep the oil from bleeding out of the grease.

To further ensure a grease's original quality and cleanliness, as well as to prevent excessive oil separation, the following storage and handling techniques are recommended:

- ✓ Do not use lubricating greases that have been stored for long periods of time unless their condition and cleanliness can be verified by a laboratory analysis.
- ✓ If accidental mixing is suspected or has occurred, consult the lubricant supplier or conduct compatibility tests.
- ✓ The storage room should be separated from areas of contamination such as metal debris, dust, dirt, chemical fumes or moisture. The room should be heated, well-ventilated and contain clean accessories, dispensing equipment and other necessities. Personnel also should be properly trained in storage techniques and inventory control to prevent contamination.
- ✓ Grease containers should be clearly labeled with the date they were received, the type and brand of grease, etc. These markings should be kept in a position where they can be easily read.
- ✓ Store grease in its original container until it is used. Drums, pails, kegs and boxes should be kept off the floor and supported by a rack, platform or blocks at least several inches high.
- ✓ Never leave grease containers improperly covered, uncovered or open. Keep them tightly sealed between uses. If the containers are stored outside, a heavy canvas tarpaulin, plastic sheet or lean-to can be used to keep off water or dirt. Drums, kegs and pails should be raised off the ground and stored either on their sides or tilted at a 45-degree angle to prevent any moisture or dirt from being drawn into the product.
- ✓ Any tools used to handle or dispense grease should be cleaned before they are used.
- ✓ Never use wooden paddles or spatulas to remove or transfer grease from containers to grease guns or other types of dispensing systems. This practice poses a high risk of contamination.
- ✓ If a barrel warmer is used, it should have some type of temperature-regulating mechanism. The grease should never be heated above 75 degrees F, and the barrel warmer should not be left on overnight or unattended. This can cause the grease to readily release its base oils or even thicken in consistency due to oxidation and thermal stress.
- ✓ Never use a torch or open flame to warm a grease container. This poses a fire hazard.
- ✓ Maintain a separate inventory and utilization record for each product. Tracking how much grease is used and on which machine or piece of equipment will help you keep an accurate inventory of lubricants.
- ✓ Use the oldest container received first.
- ✓ Before storing or using a grease, inspect the received containers for any damage such as severe dents, corrosion or moisture.
- ✓ Some type of coding and tagging system should be used to identify the contents of different lubricant containers, transfer/pumping systems, tools and pipes that carry grease throughout the plant. Make sure all transfer valves, hoses and dispensing equipment are kept clean. Seals and gaskets also should be maintained in proper condition.
- ✓ All transfer containers should be filled under clean conditions.
- ✓ Grease containers should be completely emptied before being discarded.

About the Author

Lawrence G. Ludwig Jr. is the chief chemist and technical director for Schaeffer Manufacturing. Contact Lawrence at lludwig@schaefferoil.com.

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Oil Cleanliness is Key for Alcoa's Balboa

Fernando Balboa has worked for Alcoa's alumina refinery in Point Comfort, Texas, for 40 years. He has held numerous positions within the company, starting out in production for nearly 5 years before eventually becoming a general maintenance mechanic. He currently serves as a PdM lubrication oil analysis technician, working daily with eight lubrication technicians. These lube techs ensure that all the equipment has breathers, sample ports and bottom sediment and water (BS&W) bowls so the oil can be monitored in the machinery.

Name: Fernando R. Balboa
Age: 61
Title: PDM Lubrication Oil Analysis Tech
Company: Alcoa
Location: Point Comfort, Texas
Years of Service: 40 years

Q What types of training have you had to get to your current position?

A I have taken courses in vibration, oil analysis, specific fundamental pumps, precision maintenance skills and several other courses. I am currently a certified machine lubrication technician (MLT I). I also hold certificates in vibration analysis, a certification in oils and greases, and a vibration analyst ISO Category I and ASNT Level I.

Q Are you planning to obtain additional training or achieve higher certifications?

A My goal is to obtain a MLT II and ISO/ASNT Level II because I'd like to further my knowledge in this field.

Q What's a normal workday like for you?

A In a typical workday, I am responsible for the oil storage and filtration in our plant. I make sure we have adequate inventory by monitoring what has come in and what goes out. Cleanliness and organization are important parts of my job. I make sure everything is running properly by examining filter carts, analyzing oil samples and reporting their contamination levels. I answer questions and calls from field personnel needing information about lubrication and oil sample results. I also regularly attend lubrication meetings where we discuss new technologies, failure analyses, how to resolve everyday issues and how to address maintenance issues with new equipment.

Q What is the amount and range of equipment that you help service through lubrication/oil analysis tasks?

A I ensure all areas have clean oil and that they are dispensing it properly. I am also available to help answer questions about troubleshooting equipment and automatic grease-dispensing systems. Overall, my job services the entire plant not only with oil but grease as well.

Q What lubrication-related projects are you currently working on?

A I am currently working on improving the filtration and dispensing system we have in the oil house lubrication room along with oils outside the lubrication room. We maintain 11 different types of oils with different viscosities starting from ISO 32 to ISO 680.

Q What have been some of the biggest project successes in which you've played a part?

A Some of my biggest successes have been helping with the formation of the oil cleaning room where all the plant's oil is stored and the establishment and maintenance of the lab, which includes a 5200 CSI oil analyzer.

Q How does your company view machinery lubrication in terms of importance and overall business strategy?

A Alcoa views machinery lubrication as a very essential part of reliable equipment operation, which has justified the lubrication program we have in place now. This in turn improves our working environment. Management has been fully supportive by adopting new technology when it becomes available, and because of this, we are making great progress.

Q What do you see as some of the more important trends taking place in the lubrication and oil analysis field?

A I think one of the important trends taking place in this field is that we are seeing machinery last longer and run more efficiently. There is definitely much more emphasis on equipment and its regular maintenance than in the past, and I think Alcoa has seen the benefits that proper lubrication analysis can provide.

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In its 13th year, RELIABLE PLANT has lined up some major drivers for conference tracks and sessions, ensuring that attendees will gain useful insight to all areas of machinery lubrication, oil analysis and reliability. With superior conference content, RELIABLE PLANT continues to grow annually among an elite group of experts, decision-makers and practitioners. No other forum brings these groups together and provides comprehensive coverage of trends, technologies and issues.

With two co-located conferences, Reliable Plant 2012 is the perfect learning vehicle to supply the tactics and solutions for substantial advances in plant performance and profitability. Double the horsepower….one badge = two conferences!

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ReliabilityWorld

What You'll Learn

Here's a preview of what you'll be able to do after attending Reliable Plant 2012:

- Combine PdM technology data to prevent equipment failures
- Effectively lubricate electric motors
- Reduce unplanned maintenance on rotating equipment
- Pinpoint equipment failures with oil analysis
- Get more out of an operator-based maintenance program
- Detect early bearing failure in low RPM bearings
- Pull data-rich, uncontaminated oil samples
- Use visual aids to improve your lubrication program
- Use a lubrication audit to improve equipment reliability
- Sample and monitor bearing grease
- Use criticality program to make oil analysis decisions
- Reduce maintenance costs while improving OEE
- Make better operational decisions for process machinery
- Use the pump performance curve for diagnosing equipment
- Effectively convince management to take an asset out of service
- Establish effective alarm points for oil analysis
- Conduct a basic maintenance performance assessment
- Collect usable data and conduct failure analysis
- Leverage your CMMS investment to support reliability strategy
- Improve maintenance efficiency and uptime with cloud computing
- Detect bearing faults using vibration analysis
- Select and apply open gear lubricants
- Prevent failures in VFD drives
- Stop cross-contaminating lubricants

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and make plans now to attend RELIABLE PLANT 2012!
May 1-3, Indiana Convention Center (Indianapolis, IN)

What Can You Expect?

More than 50 speakers will share their expertise on the best practices of industrial lubrication, oil analysis and reliability.

There will be a multitude of topic tracks from which to choose, a 75,000 square foot exhibit hall where you can network with hundreds of professionals who deal with the same issues you are facing, an Indy Track Tour, four pre-conference workshops and a special half-day summit just for managers.

Why Attend?

- Browse an expansive exhibit hall that features lubrication-related products and services from top vendors who will help you identify and find solutions to your company's challenges.
- Expand your knowledge base and secure answers and ideas in key learning sessions to address specific issues and needs in your plant.
- Acquire new skills and real-world deployment practices that you can immediately apply on the job.
- Network and exchange ideas with peers through receptions and special events.
- Go home with the best tools and processes to implement and sustain a successful plant reliability program.

Where Is It?

RELIABLE PLANT 2012 is held at the Indiana Convention Center (Indianapolis, IN). Indianapolis is known as America's most walkable city and is the racing capital of the world. Downtown Indy features the second largest inner-city park in the U.S., as well as a water canal system, outdoor amphitheater, zoo and running trails. The Indiana Convention Center is nestled among a social hub of museums, shopping venues and an abundance of area restaurants suitable for all palates.

With pleasant Indianapolis temperatures, a convenient geographic location that is close to a large base of manufacturers and an inviting downtown scene, RELIABLE PLANT will attract attendees from all over the globe. So, join us in Indy – the race to excellence awaits you!

WHO SHOULD ATTEND?

There is something for everyone. Whether you're an industry newcomer or a seasoned member of your plant's management team, you'll benefit from the comprehensive schedule of sessions, case studies and peer interactions.

- Asset Care Planners
- CBM Specialists
- Chief Engineers
- Design Engineers
- Engineering Managers
- Engineers
- Facility Managers
- General Managers
- Hydraulic Specialists
- Industrial Mechanics
- Infrared/Vibration Technicians
- Lab Managers
- Lube Analysts
- Lubrication Specialists
- Lubrication Technicians
- Machinery Engineers
- Maintenance Engineers
- Maintenance Foremen
- Maintenance Managers
- Maintenance Planners
- Maintenance Supervisors
- Maintenance/Reliability Managers
- Mechanical Engineers
- Operations Managers
- PdM Analysts/Specialists
- Planners and Schedulers
- Plant Engineers
- Plant Managers
- Quality Managers
- Reliability Coordinators
- Reliability Engineers
- Reliability Team Leaders
- Reliability Technicians
- Safety Managers/Directors
- Senior Reliability Engineers
- TPM Coordinators/Facilitators

….and more

Lubrication Excellence Manager's Summit

Jim Fitch, Noria Corporation
Monday, April 30, 1:00 p.m. – 4:30 p.m.

There's a revolution occurring. Managers who once desired equipment maintenance reliability now demand it…it is a matter of corporate survival in the global economy, and effective machinery lubrication is an essential enabler to success.

This movement has led companies in all industries to take control of reliability by reinventing their lubrication programs. Those who are responding to the challenge are seeing amazing results….on the bottom line, where it counts most.

The change goes beyond simply using better lubricants. The leaders are employing technologies, empowering employees and building ultramodern new practices – creating new and energized reliability culture. The workshop will address the following topics:

- Performance metrics for PM compliance, contamination control and lubricant quality targets
- How to evaluate needed lubrication and oil analysis skills
- The top 10 things organizations do wrong when trying to attain lubrication excellence
- How to benchmark your program to world-class status and construct a master plan for transformation
- The role of certification, education and continuous improvement
- How to convert 80% reactive maintenance to 80% plus proactive maintenance with diversions – and make it stick!
- How to leverage the "behavior factor" in lubrication excellence
- How to build a first-rate lubrication team with the specific collection of skills needed
- The critical role of well-aligned lubricant suppliers and machinery OEMs
- Why on-site analysis is a "secret sauce" for world-class lubrication
- What kind of return-on-investment you can expect from your program
- The importance of standardization and procedure-based lubrication
- The honest truth about synthetics and premium lubricants
- Lubrication low-hanging fruit and quick kills
- The power of the daily one-minute inspection when done correctly
- Three crucial requests to make of component rebuild shops
- How to select a lubricant supplier and what needs to be put in a supply agreement

The Manager's Summit is for managers who don't require technical expertise in the field but need enough information to plan, organize, staff and support a best practice lubrication and oil analysis program with guidance and resources.

With Full Conference Registration - $225
Workshop Only - $295

Schedule at a Glance

Monday, April 30

7:00 a.m. – 6:00 p.m.	Registration at the Indiana Convention Center
8:00 a.m. – 5:00 p.m.	Exhibit Hall Set Up
8:00 a.m. – 4:30 p.m.	Pre-Conference Workshops
5:30 p.m. – 8:30 p.m.	Certification Testing (ICML & SMRP)

Tuesday, May 1

7:00 a.m. – 6:00 p.m.	Registration at the Indiana Convention Center
7:30 a.m. – 8:00 a.m.	Continental Breakfast
8:00 a.m. – 9:20 a.m.	Opening Keynote Session
9:30 a.m. – 10:50 a.m.	Exhibit Hall Grand Opening
11:00 a.m. – 11:50 a.m.	Conference Sessions
12:00 p.m. – 1:20 p.m.	Lunch in Exhibit Hall
1:30 p.m. – 5:20 p.m.	Conference Sessions
5:30 p.m. – 6:30 p.m.	Meet and Greet Reception in Exhibit Hall
9:30 a.m. – 6:30 p.m.	Exhibition Hours

Wednesday, May 2

7:00 a.m. – 6:00 p.m.	Registration at the Indiana Convention Center
7:30 a.m. – 8:00 a.m.	Continental Breakfast
8:00 a.m. – 9:50 a.m.	Conference Sessions
10:00 a.m. – 10:50 a.m.	Refreshments in Exhibit Hall
11:00 a.m. – 11:50 a.m.	Conference Sessions
12:00 p.m. – 1:20 p.m.	Lunch in Exhibit Hall
1:30 p.m. – 5:20 p.m.	Conference Sessions
3:30 p.m. – 4:40 p.m.	Refreshments in Exhibit Hall
5:30 p.m. – 6:30 p.m.	Networking Reception in Exhibit Hall
6:00 p.m. – 9:00 p.m.	Certification Testing (ICML & SMRP)
9:30 a.m. – 6:30 p.m.	Exhibition Hours

Thursday, May 3

7:30 a.m. – 11:00 a.m.	Registration at the Indiana Convention Center
7:30 a.m. – 8:00 a.m.	Continental Breakfast
8:00 a.m. – 8:50 a.m.	Conference Sessions
8:50 a.m. – 9:20 a.m.	Refreshments in Exhibit Hall
9:20 a.m. – 11:10 a.m.	Conference Sessions
11:15 a.m.	Giveaway in Exhibit Hall
8:50 a.m. – 12:00 p.m.	Exhibition Hours

PRE-CONFERENCE WORKSHOPS

Understanding Oil Analysis Reports

Matt Spurlock, Noria Corporation

Monday, April 30 – 8:00 a.m. - 4:30 p.m.

Oil analysis is a key component in reliability programs worldwide – what isn't as readily evident is the ability to fully understand what oil analysis reports tell us. Identifying defects in a proactive manner allows a preventative repair window to address potential failures before extensive damage sets in.

In this full-day workshop, you'll learn how to identify potential and confirmed defects that register high on the P-F curve so that appropriate action can be taken before a catastrophic event occurs.

Many questions exist regarding oil analysis and related data. This workshop will help you to answer questions such as:

- What tests should be run and why?
- Why do I need so many tests and why does the lab ask for more?
- How are alarm levels established?
- What other information should be considered when evaluating oil sample data?
- How do I establish a trend and identify deviations from that trend?
- How do we use tests for cross-test data confirmation?

By the end of the workshop, the attendee will be armed with the necessary information to proactively use oil sample data to his/her advantage in the battle against poor equipment reliability.

With Full Conference Registration - $425
Workshop Only - $495

How to Extend the Life of Rolling Element Bearings

Jason Tranter, Mobius Institute

Monday, April 30 – 8:00 a.m. - 11:30 a.m.

In this workshop, you will learn the main reasons why bearings fail and exactly how vibration analysts can contribute to eliminating those root causes. Many condition monitoring professionals focus on detecting bearing faults, but too few consider how they can increase the life of the bearing through reliability improvements. Vibration analysts have the tools to learn why bearings fail and to make changes so that bearings run for many years before failure occurs.

You will learn:

- Why vibration analysts are only doing half of their job if they only work to detect faults
- How examination of vibration data can lead to the root cause of the failure
- How examining the surface of the bearing (once it fails) reveals the reason why it failed
- How reducing unbalance, misalignment, and resonance will increase the life of the bearing
- How improving lubrication and installation techniques will improve reliability

Reliability engineers, vibration analysts and anyone who has an interest in reliability and condition monitoring should attend. Detailed knowledge of vibration analysis is not required.

With Full Conference Registration - $225
Workshop Only - $295

Root-Cause Analysis Tools for Plant Equipment Failures

Rich Wurzbach, Maintenance Reliability Group, LLC

Monday, April 30 – 8:00 a.m. – 4:30 p.m.

In this workshop, you will learn how to conduct streamlined and high-value analysis of equipment failures to determine root causes and implement proactive maintenance strategies to improve reliability. Many companies utilizing diagnostic technologies like vibration analysis, infrared thermography and lubricant analysis primarily make determinations on when to repair incipient and developing failures. What's missing is the proactive maintenance approach, which requires a review of component failures and degraded conditions so that root-causes can be identified and systemic changes made to eliminate future failures from occurring.

You will learn:

- Understanding and calculating the cost of machinery failures
- The indications of impending failures and finding the warning signs in routine data sources
- Failed component evaluation for bearings, belt-drives, electrical components and others
- How to conduct effective personnel interviews after a failure
- Distinguishing causal factors and root causes
- Developing and executing corrective action plans

Instruction will include:

- Failed components for hands-on demonstrations
- Group labs for troubleshooting failed components

Reliability engineers, predictive maintenance technology practitioners and anyone who has an interest in reliability and condition monitoring should attend. Detailed knowledge of root-cause philosophies and techniques is not required.

With Full Conference Registration - $425
Workshop Only - $495

Detecting and Controlling Sludge and Varnish

Greg Livingstone, Fluitec International

Monday, April 30 – 8:00 a.m. – 11:30 a.m.

More sensitive equipment, higher stress environments and newer types of lubricants are some of the reasons that sludge and varnish have become growing concerns throughout many industries. Sludge and varnish deposits are derived from oil degradation by products. However, unlike other contaminants like dirt, water and air, oil degradation products require new analytical methodologies to detect. The removal of these by products also requires the application of different contamination control technologies. This course summarizes the various mechanisms involved in lubricant degradation and how to determine which processes are degrading your fluids. It also reviews how sludge and varnish can impair the reliable operation of your plants. Finally, clarity will be provided about the maze of potential solutions and technologies available and what appropriate technologies are suitable for different applications.

With Full Conference Registration - $225
Workshop Only - $295

General Opening Session/Featured Keynote

Davey Hamilton, "Racing Back From Adversity"

IndyCar Series driver Davey Hamilton will launch us out of the pole position during the Opening General Session with a keynote address that's bound to deliver horsepower and start your engines!

Tuesday, May 1
8:00 a.m. – 9:20 a.m.
Open to all registered attendees

Hamilton, a second-generation racer whose career was inspired by his father Ken, is a versatile driver who won championships in Super Modifieds and the famed Copper World Classic three times. He competed regularly in the IZOD IndyCar Series from 1996 to 2001 until his life was changed forever after a crash at Texas Motor Speedway in which he nearly lost his feet and legs. After 21 operations and two years of rehabilitation, Hamilton returned to IndyCar racing at the Indianapolis 500 in May 2007, and now provides driver analysis for the Indianapolis Motor Speedway Radio Network.

In February 2009, Hamilton formed a Firestone Indy Lights team with Kingdom Racing. Brandon Wagner serves as the team's driver and scored the team's first win in 2010.

RELIABLE PLANT has lined up some major drivers for conference tracks and sessions. Attendees will gain useful insight in multiple areas of industrial lubrication, oil analysis and reliability. No other forum brings industry professionals together and provides comprehensive coverage of trends, technologies and issues.

RELIABLE PLANT will feature five conference tracks – three focused on lubrication and two focused on reliability – over the course of three days. With a packed agenda of tactics and solutions for substantial advances in plant performance and profitability, here is just a sample of the learning sessions you have to choose from:

LUBRICATION EXCELLENCE SESSIONS

Devoted exclusively to using effective lubrication practices to get the most from a plant's physical equipment assets, these unique presentations, delivered by experts and successful lubrication practitioners, demonstrate how to achieve the efficiencies and financial benefits of a proper proactive lubrication program.

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Effective Electric Motor Lubrication

Jeremy Wright, VP of Services, Noria Corporation

Most electric motors are designed with grease-lubricated, anti-friction, rolling element bearings. Grease is the lifeblood of these bearings, providing an oil film that prevents the harsh metal-to-metal contact between the rotating element and races. Bearing troubles account for 50 to 65 percent of all electric motor failures, and poor lubrication practices account for most of them. In this session, you will learn how to determine the correct type of lubricant, calculate the correct amount of lubricant to use, calculate time intervals for re-lubrication and much more.

Using Criticality to Help Drive Oil Analysis Strategy

Matt Spurlock, Director of Oil Analysis Services and Technologies, Noria Corporation

Oil analysis provides a huge payback when deployed through a proper strategy. While an extremely valuable tool in today's reliability programs, it is sometimes applied in an ad hoc manner. A plant with a well-developed criticality system already has the foundation for establishing an effective oil analysis program. In this session you'll learn how to use your criticality program to establish machine selection, reliability objectives, test slate selection and sample frequency for oil analysis. The days of the common test slate and frequency are over. The largest ROI is achieved by using criticality to fine tune an existing program and to get a new program off to an optimized starting point.

The True Cost of Filtration

Christian Bauer, Pall Corporation

Industrial hydraulic and lubrication systems are at the heart of modern production processes, and effective fluid contamination control is critical in ensuring reliability and productivity. The use of filtration is instrumental in achieving and maintaining the required levels of fluid system cleanliness, but what is the true cost of filtration?

When trying to determine the true cost of filtration, plant operators must go far beyond the procurement costs for filtration hardware and filter elements and also consider the costs associated with scheduled maintenance, fluid consumption, waste disposal and system downtime, as well as energy costs. In this session you'll learn an approach of quantifying the benefits of utilizing modern, high-technology filtration, characterized by low clean differential pressure across the filter element and optimized surface area compared to conventional filtration by means of several case studies.

Setting Effective Oil Analysis Alarm Limits

Matt Spurlock, Director of Oil Analysis Services and Technologies, Noria Corporation

To properly evaluate oil sample data, you must have a solid understanding of the alarms that are in place for the various test data received. There is no "one size fits all" approach as each machine will have different reactions to given environments.

Oil analysis users should have the knowledge and tools available to establish custom alarm points for their machines. In this session, you will learn how to establish proper alarm points for wear debris, target alarms for moisture and particle contamination, and aging limits for lubricant properties analysis. Armed with this knowledge you can make an immediate impact on the health of your machines by identifying potential failures higher up on the P-F curve.

Removing Dissolved Soft Contaminants from Turbine Oil

Steffen Nyman, C.C. Jensen Inc.

Varnish can shut down a whole plant, and changing the oil is seldom the optimum solution. This presentation describes the steps in the creation of soft contaminants, their consequences, which oil analysis tests are most effective in detecting varnish precursors, varnish removal by cooling and offline filtration, as well as case studies. You'll learn the six steps in the creation of varnish

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and how to reverse them, how the oil temperature influences the solubility of varnish/soft contaminants, and how real power plants have used this technique with success.

Fuel Analysis: The Forgotten Tool of Fluid Analysis

Cary Forgeron, Analysts Inc.

Engine failures are not always related to lubrication issues. Fuel quality can have a significant impact on equipment condition and reliability. Changing regulations and the growth of bio-fuels have resulted in abnormal engine conditions. Many end-users are unaware of the benefits of fuel analysis, which can identify potential causes for fuel filter plugging, smoking, loss of power, poor injector performance, malfunctioning throttle position sensors and sticking valves. Learn how to identify common issues caused by poor or improper fuel, the common tests performed and their significance, as well as when, why and how to sample fuel.

Lubrication Basics and Best Practices

Greg Kayes, Kluber Lubrication North America

This introductory session guides attendees through the essentials of all things lubrication, from general tips to best practices. You'll learn best practices for lubricant storage and labeling, grease gun preparation procedures, bearing fill quantities, lubricant monitoring techniques, and procedures for gearbox oil changes.

Handling, Storage and Management of Lubricants

Josh Pickle, Technical Consultant, Noria Corporation

Squeezing maximum life out of lubricants and machinery starts with clean and healthy lubricants. Proactively managing lubricants from delivery and dispensing to top-ups and filling lays the groundwork for successful lubricant contamination control and enhances almost every aspect of a lubrication program. In this session you'll learn how to stop cross-contaminating lubricants, employ lubricant storage best practices and begin managing lubricants properly.

Turbine Lube Oil: Long-Term Study of Balanced Charge Agglomeration Use

Raymond Gomes, Isopur Fluid Technologies Inc.

Varnish mitigation is the biggest problem in the use of gas turbine lube oil. Varnish, the byproduct of oil degradation, coats internal components of large machines. It causes wear, bearing failure due to shaft displacement and servo valve failure. If varnish is removed from oil, the oil could last much longer than the three to five years it currently lasts, and the engine would function better. This case study looks at a long-running study of active varnish removal from turbine oil. Seven GE7FA plants located in an electric utility in the Southeast U.S. are now in their 10th year with 50,000 run hours on the initial load of oil. In this session you'll learn the method used to extend oil life and see the study's data.

Oil Sampling Best Practices

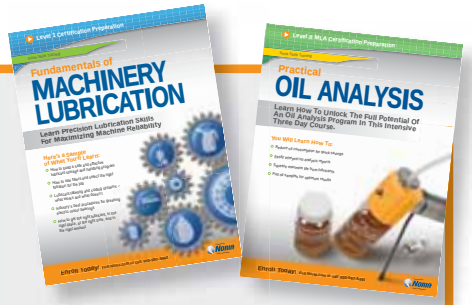
Josh Pickle, Technical Consultant, Noria Corporation

If proper oil sampling is not at the core of your oil analysis program, you could be wasting a lot of time and money on lubricant testing. Implementing a quality oil sampling program isn't difficult with the right knowledge. In this session, you'll learn how to pull data-rich, uncontaminated oil samples, how to select the right sampling locations for your machinery and procedures for pulling oil samples from systems with different pressures.

Visual Lubrication Reliability Best Practices

Mark D. Jones, Lubrication Engineers

In this session you'll learn how to make lubrication technician routes more effective, how to improve inventory control, detect water-in-oil problems, expose mixed lubricant problems and make TPM work well through visual lubrication reliability best practices. There are hundreds of ways to use visual lubrication to improve your lubrication and oil analysis programs — learn how.



FREE Noria training coupon – valued at $1,195!

Full-conference registration includes a $1,195 training coupon that can be used toward Noria's lubrication or oil analysis training courses for up to one year. Use it yourself or give it to a co-worker. It's like attending the conference and getting Noria training for free!

Terms and Conditions: Only one coupon issued per person. Coupon is transferrable within your organization and must be presented when registering for the training. Coupon is valid for Noria public training courses in the United States taking place between May 4, 2012, and May 3, 2013, or online courses purchased prior to May 4, 2013. Coupons are given to full conference (Tuesday-Thursday) attendees who pay their conference registration fee and attend the conference. Speakers and exhibitors are not eligible unless paying full conference registration fees. Coupons may not be used for onsite training.

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Environmentally Safe Lubricants in the Real World

Mark Miller, Terresolve Technologies Ltd.

Environmentally safe lubricants, fluids and greases are becoming increasingly popular for industrial equipment and can protect the users against fines, clean-up costs and downtime, but care must be given in selecting the right product for a specific application. In this session you'll learn where and when to use biodegradable fluids, how to care for biodegradable fluids, how to choose the right fluid for your applications, and the various definitions of "biodegradable". You'll also learn about environmental compatibility with stern tubes, hydraulics, pumps, sealing materials, hoses and other important components.

How to Use a Lubrication Audit to Improve Equipment Reliability

Tom Hiatt, Reliability Engineer, Covance Inc.

This session provides an overview of the development and performance of a lubrication program audit. These audits lead to the creation of an action plan that addresses the gaps in your lubrication program, and if implemented, will lead to an improvement in equipment reliability. Lubrication audits measure your current program practices against industry "best practices."

Grease Can Talk: Grease Analysis for Wind Turbines

Ruediger Krethe, OilDoc GmbH

Grease-lubricated bearings in wind turbines often fail due to lubrication and contamination issues. Grease analysis can be a powerful tool to help avoid these failures, but the analysis of used grease is a much different process than used oil analysis. In this session you'll learn how to take samples from grease-lubricated bearings, what methods should be used for monitoring the grease and how to interpret the results.

Standard Guide to Lubricant Condition Data Trending Methods

Dave Wooton, Wooton-Consulting

Lubricant condition-monitoring programs use an array of test measurements that provide a known basis for the quality of the data they are receiving. However, test measurements have little meaning in a condition-monitoring program if they cannot be associated with a failure mechanism of the oil or the machine. To address these critical aspects of condition monitoring in 2011, ASTM developed the "Standard Guide for Practical Lubricant Condition Data Trend Analysis" - ASTM D 7669. This session discusses the new standard's application and presents various trending techniques and formula along with their associated benefits and limitations. These limit and trend techniques may be utilized for all instrumentation that provides numerical test results and for all types of equipment.

TRACK TALK
FROM THE INSIDE LANE

"We're starting a new lubrication program at our plant. The conference was a good way to get some foundational skills to get things kicked off."

General Mills Employee

Grease Sampling and Analysis for Robotic Gear Drives

Rich Wurzbach, MRG Power Labs

In this session you'll learn how to obtain representative samples from grease-lubricated robotic gear drives, perform meaningful analysis with small sample quantities and perform condition-based grease replenishment. Case studies and two methods for grease sampling of Fanuc and other robotic gear drives will be discussed.

Methods of Application for Open Gear Lubricants and Their Selection

Lawrence Ludwig, Chief Chemist and Technical Director, Schaeffer's Specialized Lubricants

Open or semi-enclosed gear drives, which are also known as heavy-duty gear drives or girth gears have been one of the most common methods of power transmission since the beginning of the Industrial Revolution. Open gear drives are often the most economical type of gear drive alternative for use in applications where high load-carrying capacity and long service life under severe shock load conditions are required. Though there are different types of open gear lubricants that can be used in the lubrication of an open gear drive system the particular type of application method must always be considered in order to ensure that the right amount of open gear lubricant in the right place at the right time is properly applied to prevent wear and catastrophic failure. In this session the different methods of application, selection criteria and procedures for applying open gear lubricants will be discussed.

Eliminating the Two-Part PM: How Grease Relief Samplers Protect and Diagnose

Rich Wurzbach, MRG Power Labs

It is generally accepted as a best practice in electric motor greasing to remove the bearing housing drain plug prior to greasing and to leave the plug out for some period of time to allow purging before returning and re-installing the plug. This typically requires two visits to the same machine at different times to achieve the restoration of the drain plug. In this session, you'll learn how to use grease relief samplers to reduce the risk of over pressurization that occurs when a plug is not removed or is re-installed prematurely prior to a sufficient

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period of purging of excess grease. You'll also learn how the captured grease can be analyzed for optimizing relubrication intervals based on the condition of the grease being purged from the bearing.

Oil Analysis Case Studies: The Good, the Bad and the UGLY

Rendela Wenzel, Consultant Reliability Engineer, Eli Lilly and Company

In this session you'll hear oil analysis case studies that demonstrate what to do and sometimes what NOT to do. Attend and learn how the Eli Lilly oil analysis program prevented equipment failures, helped provide a root cause and possible countermeasures to prevent a reoccurrence, and about the integration of some vibration analysis techniques that helped to confirm the oil findings before the asset was taken out of service. Examples of using oil analysis to extend equipment life and pinpoint equipment problems as well as multiple technology integration will be presented.

RELIABILITY WORLD SESSIONS

Spotlights the winning strategies and best practices that drive reliability results to the bottom line. Industry experts deliver compelling, practical learning sessions, with particular focus on case studies where the use of effective, reliability strategies has led to measurable economic and productivity benefits.

Reliability WORLD

Improving OEE Using "Honky-Tonk" to Reduce Costs and Increase Throughput

Riad Ardahji, Div. Director of Engineering, Reliability & Lean Services, Leggett & Platt

If a machine is running at sub-optimal reliability, the entire supply chain is wasting resources and materials, with a negative impact on profitability. Honky-Tonk is an adaptation of the Jidoka principles to include machine maintenance activities to maintain higher OEE levels. When a certain condition is detected by the machine, the Honky-Tonk device plays an audio-visual signal to alert the operator in advance of the condition before the machine stops. Attend this session and learn how to use this innovative concept to reduce maintenance and supervisory costs and to empower operators to rectify problems immediately.

Pump Performance Curves: An Effective Reliability Tool

Larry Bachus, Bachus Co. Inc.

While vibration analysis and oil analysis can detect several different types of pump problems, many pump vibrations and other issues are mysterious and go undetermined. In this session you'll learn how using the pump performance curve can indicate if lube degeneration and heat are due to incorrect pump maintenance, improper pump operation or inadequate pipe and system design. You'll learn how this forgotten and abandoned tool of reliability can be used to differentiate maintenance-induced premature failure from operation-induced premature failure and design-induced premature failure, and to reduce unplanned maintenance on rotating equipment.

Thermal Growth and Machinery Alignment

Pedro Casanova, Senior Application Engineer, LUDECA Inc.

Thermal growth is a very common occurrence in rotating equipment, affecting not only the alignment of equipment but also vibration. In this session, you'll learn about the effects of thermal growth and how to deal with its effects on machinery.

The Path to Maintenance Excellence

Wayne Vaughn, Vesta Partners

Many times people want to improve their maintenance operations but either don't know where to start or choose to start in areas that have a low ROI or are not sustainable because they are not built on basic maintenance work processes that are performing well. In this session, you'll learn how to make these early decisions, how to proceed with a project and see what success will look like. You'll learn several approaches to doing a basic assessment of where you are in maintenance performance and which areas offer the highest ROI for the organization. After the session, you'll be better equipped to prioritize what needs to be done and build a business case to get the necessary resources approved.

The Key to Improving Your Availability is FRACAS

James Taylor, Machinery Management Solutions Inc.

Before you can make meaningful improvements to equipment reliability and availability, you have to collect all the pertinent information in a manner that makes it available for analysis. Part of the problem is capturing it from the trades, part is in capturing it in real time, and part is capturing it in a useable format. You then have to analyze that data to find a way to keep the event from happening again. In this session, you will see how to take a problem step by step from event initiation through solution implementation and learn simple ways to improve data capture, how to store it and how to use it. You'll learn a simple, step-by-step method of failure analysis and management, how to collect good data about your failures, how to analyze the data to find out what caused the failure, how to develop a solution that will prevent the failure from reoccurring, how to develop a procedure to apply the solution, and how to implement the procedure.

Implementing Operator Maintenance

John Crossan, John Crossan Consulting

Most management tends to believe that implementing operator maintenance is largely an operator acceptance issue, but it really has more to do with the culture of the organization, which is largely driven by plant leadership. In this session you'll learn how to educate plant leadership in the benefits and key aspects of operator maintenance, and to implement routine mechanisms that can change plant culture by building on operator maintenance to allow the plant to improve reliability and realize more of the potential of all employees.

Reliability WORLD

When Decibels Aren't Enough

Jim Hall, Ultra-Sound Technologies Training Systems (USTTS)

Airborne or structure-borne inspection of motor bearings typically requires baseline decibel readings to trend bearings for condition. With ultrasound being the earliest of warnings before vibration and heat, it can be very subjective to diagnose a condition until much later in the trend. Today's ultrasound technicians have options that can address a condition early on, such as an inner or outer race problem through waveform analysis. Spectra analysis software built for ultrasound inspections can reveal a condition at first read by displaying an FFT or time waveform condition or fault during an initial inspection. In this session you will see video of the inspection utilizing an ultrasound instrument with FFT and time waveform clearly revealing an "inner-race fault with sidebands" on the initial read of a newly installed pump motor bearing.

Tools and Techniques for Understanding Chloride Stress Corrosion Cracking

Greg Henson, Consultant Engineer-Reliability, Eli Lilly and Company

The phenomenon of chloride stress corrosion cracking is a significant problem for many companies. Elanco, a division of Eli Lilly and Company, has fallen victim to this cracking in its fermentation vessels.

Through these experiences, the site improved its understanding of chloride stress corrosion cracking. Using process and equipment data analysis, the site has created statistical models to predict and prioritize repair. Predictive tools have also been established to monitor and detect potential failures. In this session you'll learn the methods used to evaluate the sides of the stress corrosion triangle and various ways of monitoring and minimizing the effects of chloride stress corrosion cracking. The use of actual test data and statistical analysis that aided in predicting failures and the methods of repair will also be explained.

Cloud Computing - Another Buzzword or Leveraging Technology?

Randy Johnson, Azima DLI

Companies of all shapes and sizes are taking advantage of the cost and operational benefits of cloud computing, but many predictive maintenance professionals are lagging behind, as they don't understand what it is or how it can help support operational goals. In this session you'll learn how cloud computing can improve the efficiency, uptime and transparency of maintenance operations. Applications within the maintenance industry and industry case studies will be presented.

Rolling Element Bearing Fault Detection Techniques

Jason Tranter, Mobius Institute

Many people have been told about bearing vibration, and they know how important it is to detect the fault conditions. But most do not understand why the vibration changes the way it does or how spectrum analysis, waveform analysis and high-frequency techniques combine to give the clearest picture of bearing condition. In this session, you'll learn what the key bearing frequencies are, why we use high-frequency bearing fault detection techniques, how to determine the approximate time until the bearing will fail, how to detect bearing faults even if you don't know which bearings are in the machine, and why it is important to open and inspect the bearing when it is removed from the machine.

TPM Implementation: Considering Organizational Culture

George Péczely, A.A. Stádium Ltd.

The implementation process of TPM is fairly well-defined. Thousands of companies are successful with TPM, but there are also many that can't achieve good results. Why? There are a number of reasons, like the support from top management was missing, or workers did not agree, etc. But if we take a closer look, we will see that all of this comes from the organizational culture, "the way we do things here." How does the organizational culture affect TPM implementation, and where should the emphasis be placed during implementation, depending on the type of culture? The session shows the results of research aiming to find a connection between the success of TPM implementation and organizational culture. It describes the basic contexts and gives advice on how to guide implementation in different phases.

Going Deep to Prevent Catastrophic Failure in a Platinum Mine

Noah Bethel, PdMA Corporation

Some 5,900 feet below the surface, deep in the shaft of a platinum mine, is not the ideal place for a catastrophic motor failure, especially when the application controls water from flooding the mine shafts. There are those who assume that preventive motor maintenance is the best protective strategy for preventing motor failure and costly downtime. However, a South African mining company has found predictive maintenance to be a better alternative — and with good reason. The company was able to save thousands of dollars that it would have had to spend on repairs resulting from an imminent and potentially catastrophic motor failure.

The VFD Story: Hidden Damage of Shaft Currents

Dwight Vicars, Inpro-Seal LLC

The increased use of VFD drives to save energy is causing increased cases of premature bearing failures in motors, pumps and bearing blocks. This increase in failures is mainly due to shaft currents created by the use of VFD drives. In this session you'll learn why VFDs cause bearing failures, how to determine if any of your motors have an issue, the pros and cons of available solutions, and how to prevent future failures.

Solution for Monitoring Low RPM Bearings

Patrick Parvin, SPM Instrument

Low RPM applications have been notoriously difficult to monitor with traditional vibration-based techniques. The energy involved at RPMs below 50 is very low, making it a difficult task to extract meaningful information from the measured signal. Early failure detection is vital to maximizing equipment life and effectiveness. Estimating the remaining lifetime of a component and knowing when is the right time for repair are difficult at best. In this session, advanced Shock Pulse Method technology utilizing high definition algorithms to filter out irrelevant

signals and how they can be used on all types of machinery with the ability to measure in the 1 to 20,000 RPM range will be discussed. Two case studies will be presented with real-time results on machinery running at low speeds.

Maintenance Master Planning

Mike Greenholtz, Genesis Solutions

In this session you'll learn how to develop and implement a maintenance master plan to achieve sustainable best-in-class performance levels for proactive maintenance, resulting in significant OEE improvements on targeted equipment, as well as improvements in "right first time quality" metrics. You will gain a greater understanding of a progressive, multiphase maintenance master plan and how to leverage your CMMS investment to support reliability strategy.

A Holistic Approach to Assessing the Condition of Process Machinery

Robert Perez, Staff Reliability Engineer, Enterprise Products

One of the most challenging aspects of a machinery professional's job is deciding whether to shut down an operating machine due to a perceived problem or allow it to keep operating. If he is wrong, the remaining machine life is wasted, but if he is right, he can prevent his organization from experiencing undesirable consequences, such as product releases, fires, costly secondary machine damage, etc. This economic balancing act is at the heart of all machinery assessments. In this session you will learn a logical and holistic eight-step approach to assessing process machines in the field that will help you make cost-effective operational decisions and develop a more complete picture of machine condition.

Preventing Equipment Failures with Condition-Based Maintenance Tools

Rendela Wenzel, Consultant Reliability Engineer, Eli Lilly and Company

In this session, you'll learn how to combine the use of oil, vibration and thermographic analysis to prevent equipment failures. Correlating these technologies provides an even greater confidence when communicating to management that an asset is approaching an impending failure. This type of approach, referred to as the "2 out of 3 technology rule," will give a confidence level of 95 percent or greater to the reliability engineer when asking to take an asset out of production to do the necessary maintenance. You'll also learn how to create a "bomb report," which the presenter uses to effectively convince management to take the asset out of service without "data overload."

Learning sessions are being added daily – for the most up-to-date schedule of conference sessions and workshops, visit conference.reliableplant.com.

Indy Track Tour

Monday, April 30 – 1:30 p.m. – 4:30 p.m.

Get your motor running and make plans to attend a **horsepower-packed tour** at the Indianapolis Motor Speedway! Established in 1909, the Speedway has long prevailed as an icon of motorsports excellence. Known as the world's largest spectator sporting facility, it plays host annually to three events in three major racing series: Indianapolis 500 Mile Race (IZOD IndyCar Series), Brickyard 400 (NASCAR Sprint Cup Series) and Red Bull Indianapolis GP (MotoGP World Championship).

This one-of-a-kind museum excursion and Indy track/VIP grounds tour includes:

- Round-trip transportation to/from the Westin Indianapolis Hotel *(approximately 15 minutes each way)*
- Admission to the Indy Hall of Fame Museum
- 1½ - hour guided tour
- Lap of speedway
- Delivery to front straightaway at start/finish line and official "Yard Of Bricks"
- Visit to the victory podium overlooking racetrack, drivers' interview room, etc.
- Tour of the pagoda
- Ride back to gasoline alley

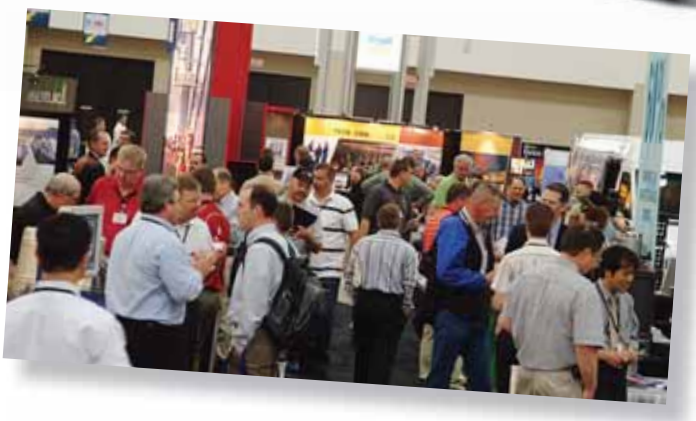
Tour attendees will depart from the Westin Hotel on Monday, April 30, at 1 p.m. and return to the hotel around 5 p.m. Cost is $60 per person inclusive. **Photo opps abound!**

Don't miss out – here's your chance to get an up close and personal insider view of Indy! **Space is limited**, so register today at conference.reliableplant.com.

Registration cut-off is Friday, March 30, 2012. No day-of registrations accepted.

Exhibitor List *as of January 23, 2012*

Make your conference experience as valuable as possible. Browse the exhibit hall and discover tools and solutions among a comprehensive group of global suppliers representing various disciplines of lubrication, analysis and reliability. Here are just a few exhibitors who are onboard for this year's event:



AESSEAL, Inc.
Air Sentry
Alemite
All-Test Pro, LLC
ALS Tribology
Analysts, Inc.

Argo-Hytos, Inc.
A.T.S. Electro-Lube International, Inc.
Azima DLI
Cannon Instrument Company
CheckFluid, Inc.
CITGO Petroleum Corporation
COT-Puritech
Delta Technologies
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Donaldson Company, Inc.
Emerson Process Management
Esco Products, Inc.
Fluidall, LLC
Fluid Technologies
Fluitec International
ForFluids.com
Genesis Solutions
Hach Company
Harvard Corporation
Henek Fluid Purity Systems, Inc.
Herguth Laboratories, Inc.
HYDAC Technology Corporation
Hy-Pro Filtration
ICML
IFH Group
Indiana Bottle Company
Inpro/Seal Company
Insight Services
ISOPure Fluid Technologies, Inc.
JAX INC. / XACT Fluid Solutions
Kaman Technologies
Kluber Lubrication North America L.P.
Koehler Instrument Company, Inc.
Lazar Scientific, Inc.
Life Cycle Engineering
Liquidynamics
Lubrication Engineers, Inc.
Ludeca, Inc.
Meggitt Sensing Systems - Wilcoxon Research
Midland Manufacturing Company, Inc.
Mobius Institute
MP Filtri USA
Noria Corporation
Oil Filtration Systems, LLC
PdMA Corporation
PerkinElmer, Inc.
POLARIS Laboratories
Predictive Sensor Technology
Pulsarlube USA, Inc
R&G Laboratories, Inc.
Rock Valley Oil & Chemical Company, Inc.
Royal Purple, Inc.
Schaeffer Manufacturing Company
Schroeder Industries
SDT North America
Shell Lubricants
SKF USA, Inc.
SMRP
Specialty Manufacturing, Inc.
Spectro, Inc.
SPM Instrument
Tannas Company
UE Systems, Inc.
Ultralube
Whitmore Manufacturing Co.
Y2K Fluid Power

Sponsors shown in orange

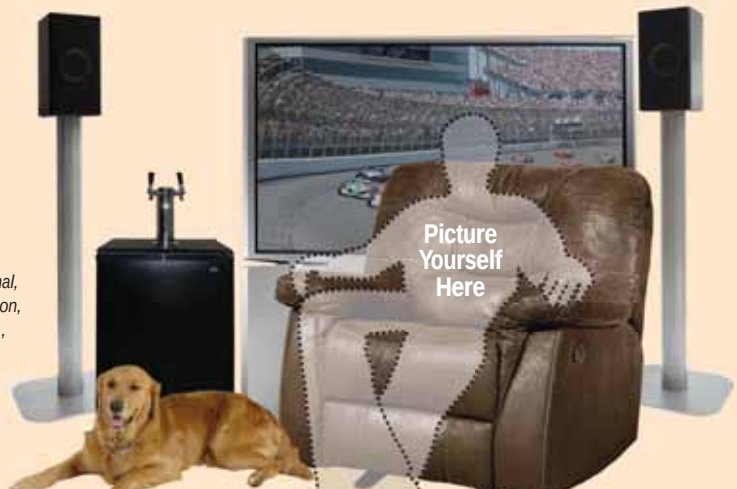
Win a High Performance Hideout!

Need a place of your own to escape but can't outfit your ideal hideaway? Let RELIABLE PLANT do it! Perhaps a turbo-charged TV room complete with 70 inch screen, Blu-Ray and surround sound system, recliners and a game table? It's all within your grasp.

How to Win: Check out the latest products and services from the sponsoring exhibiting companies in the Exhibit Hall, get your entry form stamped and then register to win! Visit conference.reliableplant.com for complete contest rules and eligibility.

Diagram shown is for demo purposes only – winner will be awarded a check to outfit his or her own High Performance Hideout!

Giveaway sponsored by:
Air Sentry, ALS Tribology, Analysts Inc., Argo-Hytos Inc., Azima DLI, CITGO Petroleum Corporation, Donaldson Company Inc., Emerson Process Management, Esco Products Inc., Fluidall LLC, Fluitec International, ForFluids.com, Hach Company, Harvard Corporation, Herguth Laboratories Inc., HYDAC Technology Corporation, Hy-Pro Filtration, IFH Group, Indiana Bottle Company, Inpro/Seal Company, JAX Inc., Kluber Lubrication N.A., Liquidynamics, Lubrication Engineers Inc., Ludeca Inc., Midland Manufacturing Company, MP Filtri U.S.A., Noria Corporation, PerkinElmer Inc., POLARIS Laboratories, Pulsarlube U.S.A. Inc., Shell Lubricants, SKF U.S.A. Inc., Specialty Manufacturing Inc., Ultralube, Y2K Fluid Power.



Hotel and Venue

Specially rated blocks of rooms are reserved at the Westin Indianapolis, which is located directly across the street from the Indiana Convention Center. You can take advantage of these discounted rates by booking your room(s) directly with the Westin using the group name "Reliable Plant Conference" at the time of reservation.

Availability is limited, and you are encouraged to make reservations early. Visit conference.reliableplant.com for more information.

Westin Indianapolis
50 South Capitol Ave.
Indianapolis, IN 46204
1-800-937-8461

Room rates – book by April 9, 2012, and save!
Single or double occupancy: $139.

**All room rates are exclusive of state and local taxes or applicable service or hotel-specific fees in effect at the time of the conference. Hotel tax rates are subject to change without notice.*

Reserve your room today!

- Call the Westin at 1-800-937-8461
- Be sure to mention Noria Corporation or RELIABLE PLANT 2012
- Make all hotel reservation changes or cancellations directly with the Westin

Official Airlines and Car Rental

Air Travel

American Airlines is offering discounted fares for attendees of RELIABLE PLANT 2012. Some restrictions may apply for airline tickets and discounts may not be available on all fares. For reservations and ticketing information, call American's Meeting Services Desk at 1-800-433-1790 anywhere in the U.S. or Canada and reference authorization number: **7142BU**.

Discount fares are valid for round-trip travel on American Airlines and American Eagle and can be booked online at www.aa.com/group without a ticketing charge. Valid group travel dates are April 28 to May 7, 2012.

United Airlines is offering discounted fares for attendees of RELIABLE PLANT 2012. Some restrictions may apply for airline tickets, and discounts may not be available on all fares. For reservations and ticketing information, call United Meetings at 1-800-521-4041 and refer to group code: **587JR**. Valid group travel dates are April 26 to May 9, 2012.

Car Rental

Discounted group car rental rates are available from April 28 to May 7, 2012. Reservations can be made by calling 1-800-331-1600 or online at www.avis.com and referencing discount code: **J906910**.

Discounted group car rental rates are available from April 25 to May 11, 2012. Reservations can be made by calling 1-800-654-2240 or online at www.hertz.com and reference discount code: **CV#04NZ0002**.

TRACK TALK
FROM THE INSIDE LANE

"It's been a very good conference – full of very practical hands-on sessions and excellent take-home information that can be readily applied."

Jerry Sanders, Michelin

HOW TO REGISTER

REGISTER before March 30 and save $200

Register Using Any of the Following:

Online:
conference.reliableplant.com

By Phone:
Call us at 800-597-5460 or 918-749-1400 M - F 8 a.m. to 5 p.m. (CST)

By Fax:
Fax your completed registration form 24 hours a day to 918-746-0925

By Mail:
Send your registration form with payment or PO to:
Noria Corporation
1328 E. 43rd Ct.
Tulsa, OK 74105 U.S.A.

On Site:

Monday, April 30	7:00 a.m. – 6:00 p.m.
Tuesday, May 1	7:00 a.m. – 6:00 p.m.
Wednesday, May 2	7:00 a.m. – 6:00 p.m.
Thursday, May 3	7:30 a.m. – 11:00 a.m.

Full Conference Registration

On or before March 30, 2012	$795
After March 30, 2012	$995

Full-Conference Registration Includes:

- Admission to all break-out conference sessions (Tuesday-Thursday, May 1-3)
- Conference proceedings on CD-ROM
- Opening general session and keynote speaker (May 1)
- Exhibition hall access (Tuesday-Thursday, May 1-3)
- Lunches in the exhibit hall (Tuesday-Wednesday, May 1-2)
- Daily refreshment breaks (Tuesday-Thursday, May 1-3)
- Daily continental breakfasts (Tuesday-Thursday, May 1-3)
- Networking receptions (Tuesday-Wednesday, May 1-2)
- FREE Noria training coupon, valued at $1,195

Group Discounts

3 to 9 attendees: Send three or more full-conference registrations for only $550 each, plus a 30% discount on all pre-conference workshop fees.

10 or more attendees: Send 10 or more full-conference registrations for only $350 each, plus a 30% discount on all pre-conference workshop fees.

One-Day Conference Registration $395

- Admission to one day of break-out conference sessions (choose from Tuesday, Wednesday or Thursday)
- Opening general session (Tuesday only, May 1)
- Exhibition hall access for one day (choose from Tuesday, Wednesday or Thursday)
- Lunch in the exhibition hall for one day (Tuesday or Wednesday, May 1 or May 2)
- Day's refreshment breaks
- Day's continental breakfast
- Day's reception (Tuesday or Wednesday, May 1 or May 2)

Exhibition-Only Registration

With exhibitor guest pass (all three days)	FREE
Without guest pass (all three days)	$50

Pre-Conference Workshops

Monday, April 30

Half day with full-conference registration	$225
Half day with workshop only	$295
Full day with conference registration	$425
Full day with workshop only	$495

Workshop registration includes:

- Course materials
- Refreshment breaks
- Opening general session (Tuesday, May 1)
- Exhibition hall access (Tuesday, May 1)

Spouse/Family Registration $135

- Opening general session (Tuesday, May 1)
- Exhibition hall access
- Daily lunches in the exhibition hall (Tuesday-Wednesday, May 1-2)
- Daily continental breakfasts (Tuesday-Thursday, May 1-3)
- Receptions in the exhibition hall (Tuesday-Wednesday, May 1-2)

Certification

The International Council for Machinery Lubrication (ICML) will offer certification exam opportunities during RELIABLE PLANT 2012. Advance registration is required. All exams will be conducted at the Indiana Convention Center on Monday, April 30, from 5:30 p.m. to 8:30 p.m., and on Wednesday, May 2, from 6 p.m. to 9 p.m. To learn more about the certification types, registration fees and exam preparation, visit the ICML website at www.LubeCouncil.org or call 918-259-2950.

The Society for Maintenance & Reliability Professionals (SMRP) will also offer onsite certification exam opportunities on Monday, April 30, from 5:30 p.m. to 8:30 p.m., and on Wednesday, May 2, from 6 p.m. to 9 p.m., at the Indiana Convention Center. Advance registration is required. Please visit the SMRP website at www.smrp.org or call 1-800-950-7354 to select your certification and ensure your seat in one of the testing sessions.

RELIABLE PLANT 2012 REGISTRATION FORM

May 1-3, 2012 – Indiana Convention Center, Indianapolis, Indiana

1. Registrant Information

Please print your name clearly. Your name and company will appear on your badge.

PLEASE photocopy this form for an additional registrant.

First Name_____

Last Name_____

First Name for Badge_____

Title_____

Company_____

Address 1_____

Address 2_____

City_____State/Province_____

Zip/Postal Code_____Country_____

E-mail (required)_____

Phone Number (required) (_____)_____

Fax Number (_____)_____

2. Conference Fees

Individual Full Conference:

☐ Through 3/30/12 .....$795
☐ After 3/30/12 .....$995
☐ **Guest-Spouse/Family**.....**$135**
(Must accompany paid attendee)

Individual 1-Day

☐ Individual 1-Day.....$395
☐ Exhibition Hall Only.....$50

Endorsing Organization Member

☐ Through 3/30/12 .....$745 ☐ After 3/30/12.....$945

Write-in Organization _____

Group Discounts

Three to nine full conference registrations only $550 each or 10 or more for $350 each. Group discounts include a 30% discount on pre-conference workshop fees. Group registrations must be purchased at the same time. Call 800-597-5460 to take advantage of this offer.

BEST VALUE!

3. Pre-conference Workshops

Monday, April 30		Save With Full Registration
Lubrication Excellence Manager's Summit	$295	$225
Detecting and Controlling Sludge and Varnish	$295	$225
How to Extend the Life of Rolling Element Bearings	$295	$225
Root-Cause Analysis Tools for Plant Equipment Failures	$495	$425
Understanding Oil Analysis Reports	$495	$425

4. Track Tour

Monday, April 30

☐ Indianapolis Motor Speedway Track Tour……..……$60 per person
Includes round-trip transportation from Westin Hotel, admission to museum, guided tour of speedway, media center and various track areas.
Space is limited – registration closes on Friday, March 30, 2012

5. Conference Proceedings on CD-ROM

☐ With full-conference registration.....Included

☐ Purchase without registration.....$99

Total Payment Due: $_____

Payment due upon receipt of invoice and prior to conference. No registration materials will be distributed without full payment. Customers outside the U.S.: We accept checks drawn on U.S. banks in U.S. dollars.

6. Method of Payment

Payment must be received prior to the conference.

☐ Check # _____ is enclosed or will be mailed
Please make check payable to: Noria Corporation

☐ Charge my: ○ Visa ○ MasterCard ○ AmEx ○ Discover
Noria Corporation is authorized to charge the credit card below for my conference registration fees in the amount indicated on this form.

Card Number_____

Expiration Date _____ - _____

Name on Card_____

Cardholder's Signature_____

☐ Bill Me/My Company - Purchase Order No._____

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Call us at 800-597-5460 or
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By Fax:
Fax your completed registration form to:
918-746-0925

By Mail:
Send this form and payment:
c/o Noria Corporation
1328 E. 43rd Ct.
Tulsa, OK 74105 U.S.A.

Cancellations/Substitutions

Cancellations must be in writing and postmarked by March 30, 2012. All cancellations received after this date are subject to a $75 administrative fee, but you will also receive a $75 coupon good for use against the cost of a Noria training or conference. If you don't cancel and you don't attend, you will be charged the full registration fee. However, a company may substitute one attendee for another, without penalty. Written notice prior to the event is required for substitute attendees.

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TEST your KNOWLEDGE

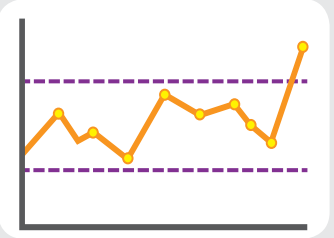
This month, *Machinery Lubrication* continues its "Test Your Knowledge" section in which we focus on a group of questions from Noria's Practice Exam for Level I Machine Lubrication Technician and Machine Lubricant Analyst. The answers are located at the bottom of this page.

1. The primary reason that machinery is replaced is due to:

A) Erosion
B) Accidents
C) Obsolescence
D) Surface degradation of the metal
E) Corrosion

2. Upper and lower alarm limits are generally needed on which oil analysis test results?

A) Acid number
B) Base number
C) Viscosity
D) Flash point
E) RPVOT



3. Which is the most common type of grease thickener?

A) Lithium
B) Barium
C) Polyurea
D) Calcium
E) Aluminum

4. Elastohydrodynamic lubrication (EHL) is considered to occur primarily in:

A) Piston rings and liners
B) Journal bearings
C) Rolling bearings, gears and cams
D) Slow-moving pins and bushings
E) Worm gears

5. Sampling crankcase oil from an engine should be done:

A) Through the dipstick hole with a drop-tube
B) From a valve mounted after the pump and after the filter with the engine running
C) From a valve mounted after the pump, before the filter with the engine running
D) From a valve mounted after the pump, before the filter with the engine shut off
E) From the drain plug

Answers: 1-D, 2-C, 3-A, 4-C, 5-C

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TO THE NEW GENERATION
OF AUTOMATIC LUBRICATORS
PULSARLUBE M
Intelligent
Powerful
Reliable
✓ Advanced Technology Control
✓ Large LCD & User Panel for Easy Programming
✓ Unrivaled Output Pressure of over 1,100 PSI
✓ Positive Displacement Pump for Precise Lubrication
✓ Built to Last on High Vibration Machinery
✓ Innovative Design for Better Protection of Your Equipment
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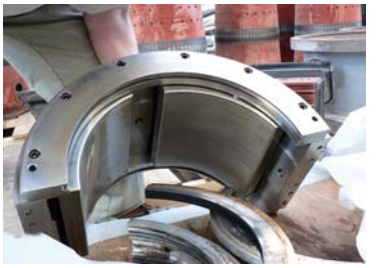

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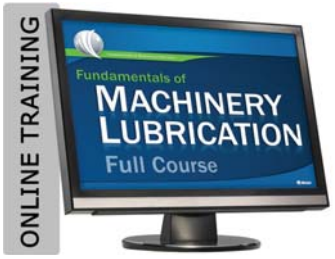

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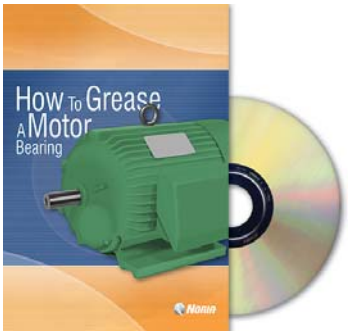

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By Paul Michael, Milwaukee School of Engineering, Fluid Power Institute

Minimizing the Impact of Built-in Contamination in Hydraulic Systems

It is widely recognized that contamination creates problems in hydraulic fluid power systems. The explanation is straight-forward — minimizing the gaps or clearances between moving parts improves efficiency and permits precise machine control. Particles compromise efficiency through abrasive wear and interfere with machine control when they become lodged in hydraulic valves.

Hydraulic equipment manufacturers have found that built-in contaminants introduced through the assembly of dirty components increase warranty costs. Three common strategies are employed by hydraulic equipment manufacturers to minimize the impact of built-in contamination:

1) Establish contamination limits for new components.

2) Verify that components comply with contamination limits.

3) Flush the assembled system to achieve roll-off cleanliness target.

Set Contamination Limits

Establishing the contamination limits for components, like most other engineering decisions, involves a cost/benefit analysis. While it is obvious that a clean part is preferable to a dirty part, there is a cost associated with achieving a given level of cleanliness. Therefore, it is prudent to consider the contamination sensitivity and working pressure of a hydraulic system when establishing contamination limits.

COMPONENT	VOLUME-TO-AREA RATIO
Reservoirs	1 to 5
Hoses and Tubes	0.2
Cylinders	0.5 to 0.6
Pumps and Motors	0.001 to 0.05
Valves	0.001
Complete Systems	0.2 to 4

Table 1. Volume-to-area ratio of hydraulic components

Generally, contamination limits for components are specified in terms of the milligrams (mg) of contamination and the length (longest chord) of the largest particle. As shown in Table 1, the volume-to-area ratio of hydraulic components covers several orders of magnitude. (Area, in this case, only applies to wetted surfaces that are in direct contact with the hydraulic fluid.)

In order to account for differences in volume and wetted surface area, different units of measure are used to define built-in contamination levels. Table 2 provides a list of contamination limits for new components expressed in common units of measure. For components that have a high volume-to-area ratio, mg/liter is a common unit of measure. For components that have a low volume-to-area ratio, mass per unit weight or mass per unit area is more appropriate. The main reason for this is that the lower limit of detection in gravimetric contamination analysis is between 1 and 2 mg. This limit is not a function of accuracy of the analytical balance but is the result of variation in the solvent and moisture absorption by the filter membrane used in gravimetric analysis.

UNIT OF MEASURE	TYPICAL RANGE
Mass per unit volume (mg/liter)	3 to 10
Mass per unit weight (mg/Kg)	0.5 to 5
Mass per unit area (mg/M^2)	25 to 1,000
Mass per unit length (mg/M)	6 to 12

Table 2. Upper control limits for built-in contamination of hydraulic components

A common mistake in establishing component cleanliness specifications is to express limits in terms of an ISO contamination code. This is understandable since ISO codes are well-known shorthand for specifying hydraulic fluid cleanliness. However, contamination codes, as defined by ISO 4406, only apply to fluids, so to specify a maximum ISO 18/16/13 contamination code for a hose, tube, valve, cylinder, pump, reservoir, etc., is incorrect. This limit might be suitable as a roll-off cleanliness specification for an assembled vehicle, but to use it for components is problematic on

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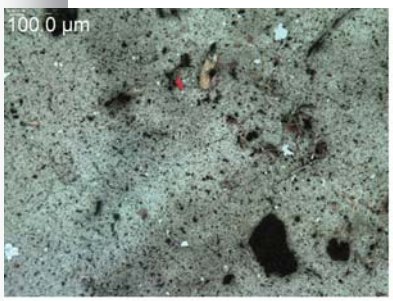


Figure 1. Debris from a new hose

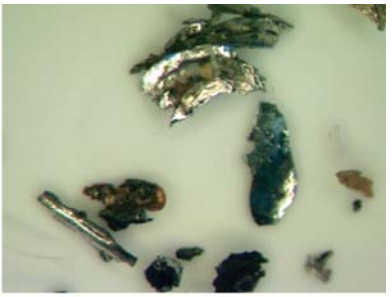


Figure 2. Debris from a new valve

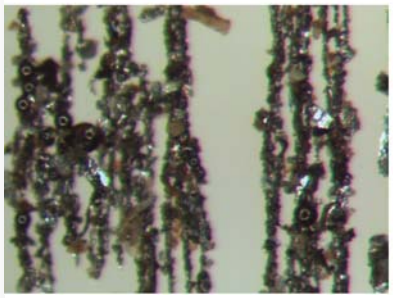


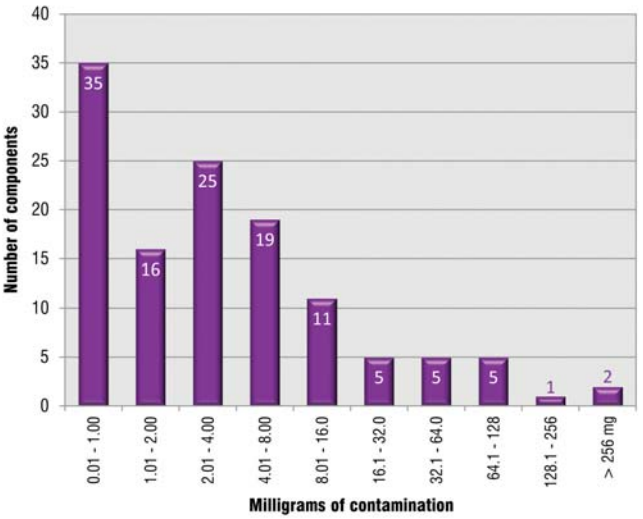
Figure 3. Debris from a new reservoir

Figure 4. Debris from a new cylinder

several levels. Of particular concern is the fact that the ISO 4406 contamination code makes no distinction between 15, 150 or 1,500 micron particles. Large particles are of great concern in new hydraulic components because they can cause severe damage the first time the system is powered up.

Verify the Cleanliness Level

Built-in contamination may be extracted from hydraulic components through pressure rinsing, ultrasonic cleaning, agitation and functional bench-test methods. A light petroleum distillate, such as filtered mineral spirits, is the preferred extraction fluid because it is an effective cleaner that does not promote rust or interact with the filter membrane used to quantify the contamination level.



Graph 1. New component contamination levels

The ISO 4405 gravimetric procedure is the standard method for quantifying the contamination level of hydraulic components. In this test method, particles are separated from the extraction fluid through vacuum filtration. The filter medium is dried in a non-ventilating oven, and the weight change (in milligrams) is recorded. Usually the length of the largest hard particle is also determined through microscopic inspection of the filter membrane.

The Fluid Power Institute recently evaluated the contamination level of more than 100 new hydraulic components. This data set included hoses, tubes, fittings, valves, cylinders, pumps and reservoirs. As can be seen in Graph 1, the contamination level in one-third of the new components exceeded 8 mg. Abrasive dirt and debris from these components will attack the rest of the hydraulic system as soon as the machine is powered up.

The process of manufacturing components produces contamination. Cutting a hose to length makes rubber and metal particles, as shown in Figure 1. Machining a valve manifold creates cutting chips, as shown in Figure 2. Fabricating a steel reservoir generates welding spatter, as shown in Figure 3. Welding the end caps on a hydraulic cylinder produces iron-oxide, as shown in Figure 4. In all cases, post-processing is required to prepare components for use in a fluid power system.

Flush the Assembled System

The assembly and filling process introduces particles into a hydraulic system. Therefore, it is a common practice to verify the contamination level of new systems as they are undergoing functional tests on the assembly line. Portable online particle counters are the preferred instruments for checking the cleanliness level. Online particle counters provide a rapid means of analysis and are not susceptible to the pitfalls of bottle sampling.

The roll-off cleanliness target for a hydraulic system should be based upon contamination sensitivity and working pressure, as shown in Table 3. In some equipment, the system can be cleaned by simply cycling the actuators. If the system incorporates components that do not completely discharge or return fluid to the reservoir, it may be necessary to use an auxiliary flushing cart to achieve the desired cleanliness level.

SYSTEM PRESSURE	CONTAMINATION SENSITIVITY	
	HIGH	MEDIUM
≤ 2300 psi (160 bar)	17/15/12	19/17/14
> 2300 psi (160 bar)	16/14/11	18/16/13

Table 3. Roll-off cleanliness targets for new hydraulic systems

Once a system is assembled, purified and shipped to the customer, it should remain sealed to prevent contamination. Oil changes in the first 2,000 hours of machine operation frequently do more harm than good. This is because new oils are not necessarily clean, and end users often lack the equipment required to filter fluid into the system.

Starting a machine with a clean hydraulic system is the first step in achieving long and reliable equipment life.

Welcome to *Machinery Lubrication's* Bookstore, designed to spotlight lubrication-related books. For a complete listing of books of interest to lubrication professionals, check out the Bookstore at store.noria.com.

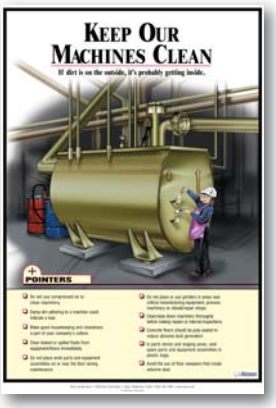
Best Practices for Lubricant Storage and Handling Training Video

Format: DVD
Publisher: Noria Corporation

Squeezing maximum life out of lubricants and extending machine life starts with putting a healthy, clean lubricant into the machine. In this training video, you'll learn the very best practices for new oil storage and handling, as well as procedures you can implement right away for managing lubricants from delivery to dispensing to filling the machine.

Keep Our Machines Clean Poster

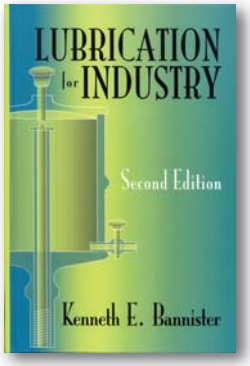
Publisher: Noria Corporation



This poster features 10 bulleted tips to remind everyone that contamination control of lubricated machinery is essential. When dirt is on the outside of equipment, it can easily get into the lubricant. Use this laminated poster to send a clear message that contamination control and lubricant quality are important to your organization.

Lubrication for Industry – Second Edition

Author: Kenneth E. Bannister

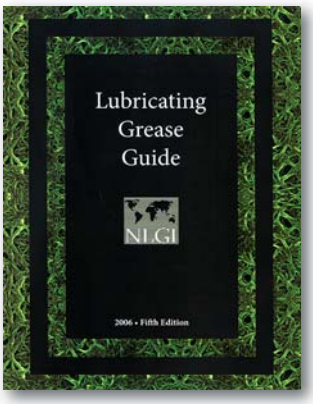


This book provides a fundamental understanding of how and why effective lubrication practices are an essential aspect of industrial equipment maintenance. Written for maintenance managers and practitioners, it focuses on the practical daily aspects of lubrication that impact productivity and includes 10 case studies that emphasize the importance of developing and implementing long-term solutions.

Lubricating Grease Guide

Author: NLGI

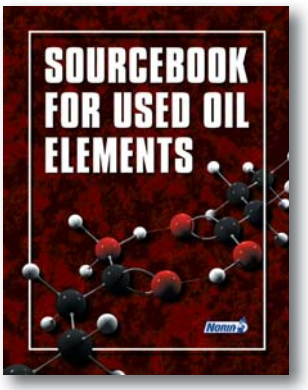
This handy quick-reference book contains material pertaining to a broad spectrum of grease-related subjects and is written by technicians for the beginner or the practitioner who wants to broaden his knowledge base. You will learn when and how to select the right grease for your machinery and easily determine which greases are compatible.



Sourcebook for Used Oil Elements

Author: Jim Fitch

Does your oil analysis report reveal chromium in your hydraulic fluid, manganese in your compressor lubricant or copper in your gear oil? Quit guessing what these elements are and how they got into your oil. This book can help you pinpoint the source. Use it to look up the sources of various elements in engines, transmissions, differentials, compressors, industrial bearings, hydraulic system components, etc.



Best Practices for Oil Sampling Training Video

Format: DVD
Publisher: Noria Corporation

Correct and accurate sample collection is the critical first step in a successful oil analysis program. Without representative oil samples, oil analysis may just be a waste of time and money. This 48-minute video shows you how to design and implement a world-class oil sampling program that will deliver better results and help you focus on improving equipment reliability.

For descriptions, complete table of contents and excerpts from these and other lubrication-related books, and to order online, visit: **store.noria.com** or call **1-800-597-5460, ext. 204**

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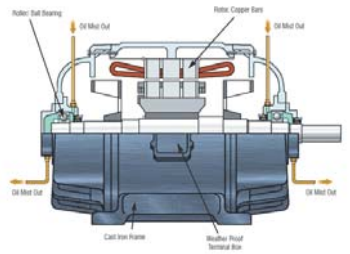
Oil Mist-lubricated Pumps and Electric Motors

Oil mist lubrication has been successfully used for pumps and their electric motor drivers in petrochemical plants since the 1960s. It is a key part of an API-based maintenance program at many refineries. Read this article on the ML site to get an overview of oil mist lubrication, along with a brief review of past and current best practices in pumps and electric motors.



Finding the Root Causes of Oil Degradation

A lubricant in service is subjected to a wide range of conditions that can degrade its base oil and additive system. By approaching lubricant degradation issues with an open mind and by methodically applying oil analysis tools, the root cause of recurring problems can be solved. Learn some of the common fluid degradation mechanisms and the tools available for identifying fluid degradation issues by reading this article on the ML site.

How to Prevent Compressor Oil Loss

Understand the causes and effects of oil loss, the difference between oil loss and the lack of lubrication, as well as what you can do to prevent this problem and avoid compressor failure. Access this 12-minute, 2-second video at www.machinerylubrication.com.

Bulk Lubricant Storage and Handling

Proper lubricant storage is critical to maintaining a clean and healthy fluid. Many things can happen to the lubricant between bulk delivery and dispensing to the machine application. Adhering to some general recommended practices for the storage and handling of bulk lubricants can greatly improve the chances of having healthy machines with long service lives. Find this article in the lubricant storage and handling section on the ML site.

The True Cost of Bearing Lubrication

This video explains how bearing lubrication failures affect your budget and the environment. Included are a definition of bearing technologies, leading causes of bearing failure, maintenance and total ownership costs, and the environmental costs of lubrication. Access this 30-minute, 38-second video at www.machinerylubrication.com.

By the Numbers

32% of machinerylubrication.com visitors do not set target cleanliness levels for critical gearbox lubricants

40% of lubrication professionals have not completed any oil analysis training, based on survey responses from machinerylubrication.com

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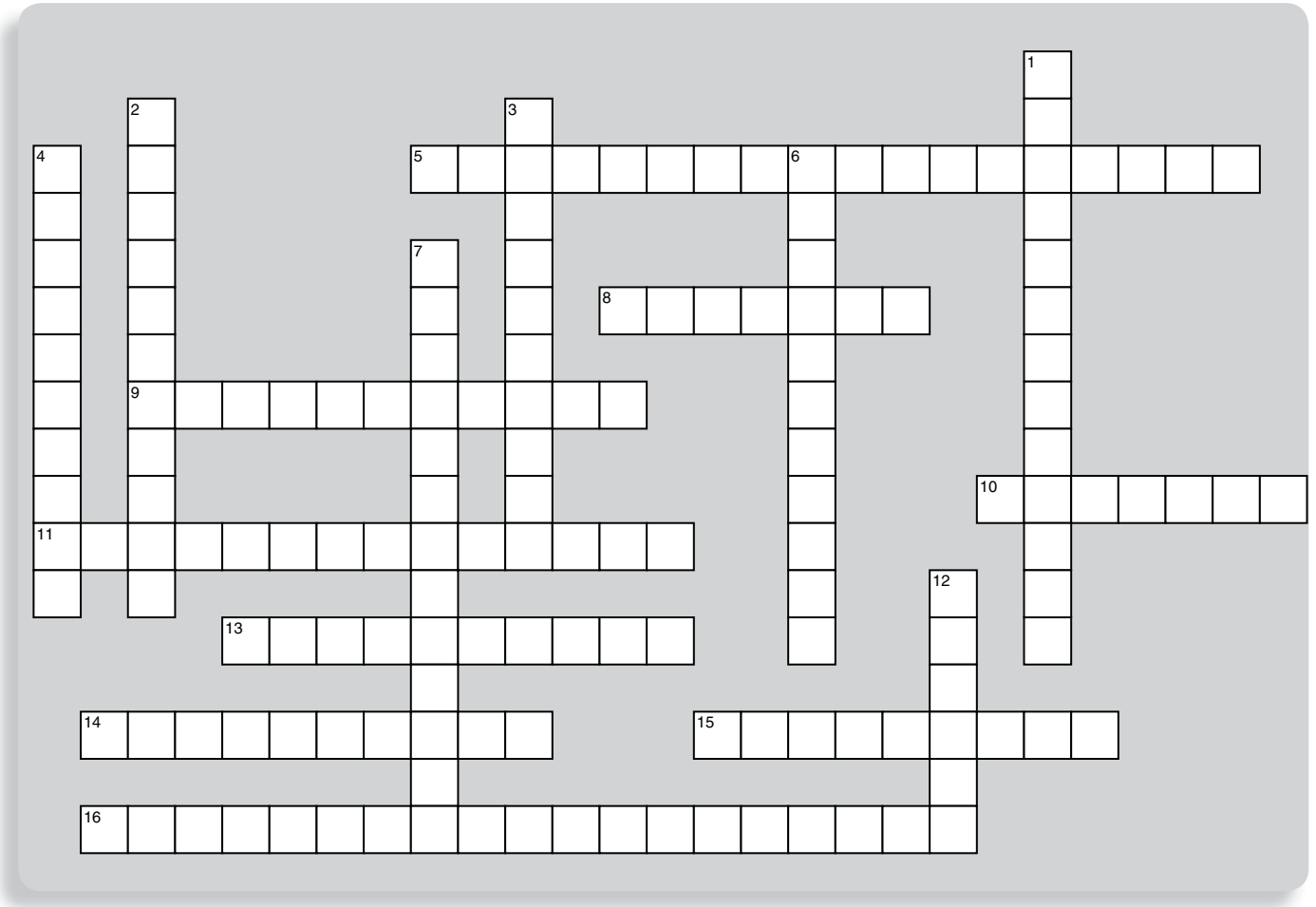


ACROSS

5 The time required for a fixed amount of an oil to flow through a capillary tube under the force of gravity.

8 A soft, white, non-ferrous alloy bearing material composed principally of copper, antimony, tin and lead.

9 A container in which fluid is stored under pressure as a source of fluid power.

10 A fluid used to remove heat.

11 A group of synthetic lubricants with superior fire resistance.

13 Engineering science pertaining to liquid pressure and flow.

14 A unit of absolute viscosity.

15 The release of a contaminant that was initially captured by the filter medium.

16 A black, lustrous powder that serves as a dry-film lubricant in certain high-temperature and high-vacuum applications.

DOWN

1 The temperature at which a grease passes from a semisolid to a liquid state.

2 The control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact.

3 Engineering science pertaining to gaseous pressure and flow.

4 Property of a lubricating grease manifested by a softening in consistency as a result of shearing.

6 A property of a solid-liquid system manifested by the tendency of the liquid in contact with the solid to rise above or fall below the level of the surrounding liquid.

7 The potential of a system for particle attraction and adhesion.

12 Insoluble material formed as a result of deterioration reactions in an oil or of contamination of an oil, or both.

Get the solution on page 63

Survey Results Confirm VALUE of CERTIFICATION

By Suzy Jamieson, ICML

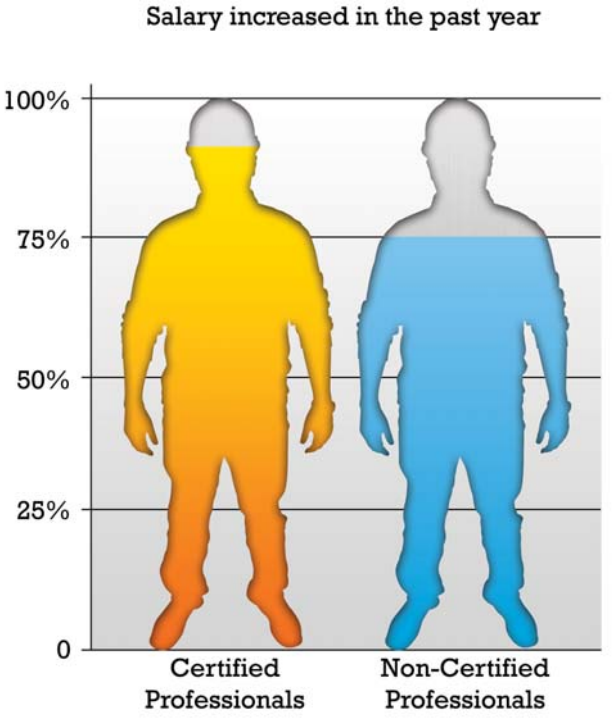
A recent *Machinery Lubrication* survey of lubrication professionals in the United States revealed some interesting trends and also shed light on just who is taking care of our lubricated equipment.

Many of the survey's respondents reported being employed by well-known and respected companies in industry that have had lubrication personnel certified by the International Council for Machinery Lubrication, with some of the companies being founding members of ICML.

According to the results, professional certification has become a requirement for career and earnings advancement in several cases, which is confirmation of skill-based pay (over seniority) as a trend. Survey respondents holding some type of professional certification reported 10 percent higher salaries than their non-certified peers, were among the most likely to have received a raise in 2011 and also were more likely to serve as a supervisor than those without a certification.

While it was gratifying to see the survey quantify the benefits of certification to ICML members in terms of remuneration, career advancement, supervisory positions and even the number of hours worked per week, it was equally exciting to see the personalities and work ethic of these workers shine through.

Easily noted in the respondents' comments provided in the survey were their commitment to quality and their desire for recognition of the criticality of their function within their company and industry. Many expressed concerns regarding apathy of peers resistant to change and the lack of management's awareness of not only the criticality of their role but also the resources needed to deliver high-quality results.



About ICML

The International Council for Machinery Lubrication (ICML) is a vendor-neutral, not-for-profit organization founded to facilitate growth and development of machine lubrication as a technical field of endeavor. Among its various activities, ICML offers skill certification testing for individuals in the fields of machine condition monitoring, lubrication and oil analysis. ICML is an independently chartered organization consisting of both paid professional staff members and volunteer advisors. It provides lubrication and oil analysis standard development support, scholarship, skill-based testing and certification, and recognition of excellence. For more information about ICML, visit www.lubecouncil.org.

The highlight of the survey may have been in the job satisfaction area, where the responses matched the profile of many ICML members and industry practitioners, demonstrating passion for what they do, being moved by the challenge and not giving up on "the cause" despite such low recognition across industry.

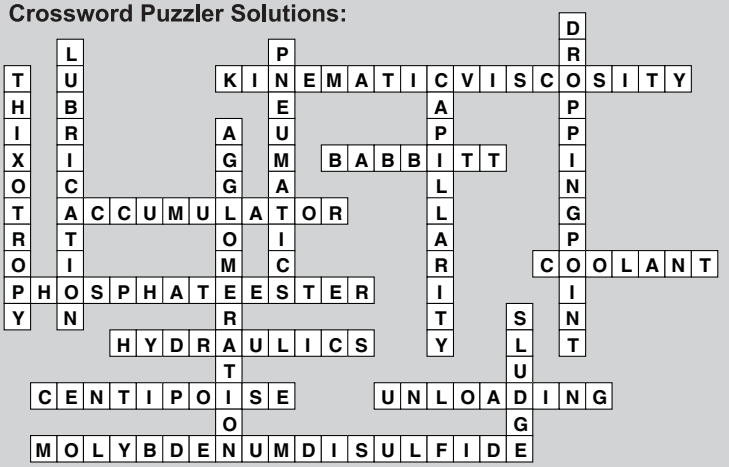
Most characteristic of who these workers are could be seen in their rating of "challenge and stimulation of the job" at the top of the list of reasons for job satisfaction, which was almost three times as high as salary and benefits. Because these individuals are dedicated and proud of their roles, naturally "lack of recognition" was the factor most frequently given for dissatisfaction with their jobs.

What can be learned from this survey is that lubrication professionals should be valued and recognized for the worth they possess and for the direct criticality of their function to the success of operations. These individuals should be empowered with the needed resources, including knowledge through accountability of training followed by certification and fair compensation. The result will be loyal, hard-working, dedicated, in-house experts who value being part of a team more than even the possible monetary rewards.

These are true professionals who take pride and responsibility in the success of their roles. They are machine lovers who are the key to reliability-centered, best-in-class lubrication. These front-line men and women are the walking, talking human factor of reliability. They are where your asset-management journey begins if you run a business heavily dependent on lubricated equipment. They are driven by passion, a love for challenge and a focus on doing things right.

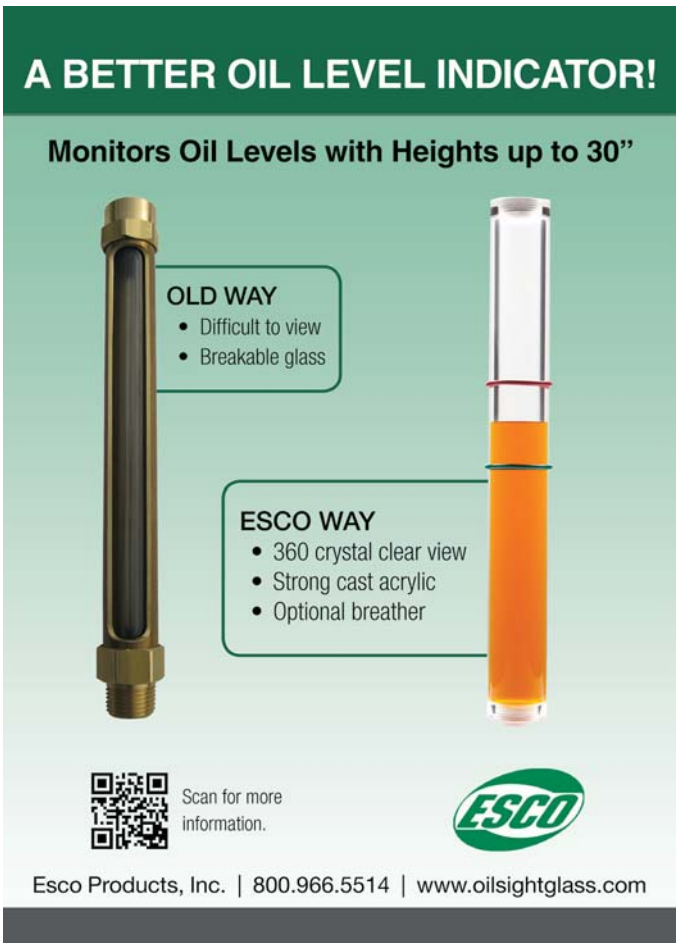
From page 61

Crossword Puzzler Solutions:



When your company achieves a world-class lubrication program, be sure to give them extra support for recognition by encouraging them to apply for ICML's John R. Battle Award for Excellence in Machinery Lubrication.

For the complete survey results, visit www.machinerylubrication.com. For more information on the John R. Battle Award and ICML certification credentials, visit www.lubecouncil.org or e-mail info@lubecouncil.org.



RECENT RECIPIENTS OF ICML CERTIFICATIONS

The International Council for Machinery Lubrication (ICML) would like to congratulate professionals worldwide who have recently achieved certified status through ICML's certification programs. ICML offers certification in the areas of oil analysis and machinery lubrication. The following is a list of recently certified professionals in the area of machinery lubrication who have attained their status as a certified Machine Lubricant Analyst (MLA), Machine Lubrication Technician (MLT) or Laboratory Lubricant Analyst (LLA).

Ken Reid, MLT I
Emmanuel Garcia Galvan, MLA I

ADEMINSAC
Edgar Gutierrez Saavedra, MLT II & MLA III

Advanced Technology Services
Christopher Suggs, MLT I
Marty Bilbrey, MLA I
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February 7-9, 2012
Birmingham, AL

March 6-8, 2012
Tulsa, OK

April 3-5, 2012
Philadelphia, PA

May 22-24, 2012
Houston, TX

June 12-14, 2012
Orlando, FL

July 10-12, 2012
Milwaukee, WI

Advanced Machinery Lubrication

April 3-5, 2012
Philadelphia, PA

Advanced Oil Analysis

March 6-8, 2012
Tulsa, OK

Practical Oil Analysis

February 7-9, 2012
Birmingham, AL

May 22-24, 2012
Houston, TX

July 10-12, 2012
Milwaukee, WI

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BACK PAGE BASICS

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HOW DESICCANT BREATHERS CONTROL CONTAMINATION

To combat the ingression of particles into oil systems, breathers are often attached to reservoirs and other oil storage components. Whether they are connected to an expensive piece of machinery or a drum of oil, breathers offer the peace of mind that as the oil level fluctuates, the air filling the space will be properly cleaned and mostly free of contaminants.

Desiccant breathers provide a wide range of benefits and are becoming more common. However, you may wonder how a plastic cup full of what looks like plastic beads actually filters incoming air and removes not only harmful particles but also water vapor, which is so dreaded in lubrication systems. The answer involves chemistry.

These breathers use the inherent qualities of two of nature's most absorbent materials — silica and carbon. Everyone likely has opened a package and found little packets marked "Do not eat." This is the same silica in desiccant breathers. How it works is quite simple. Silica is a very porous material that can trap and hold nearly 40 percent of its weight in water. As water vapor passes around these beads, it is trapped in the pores of the silica. Any water vapor that isn't trapped by the silica goes through a layer of activated carbon.

Electronegativity is a chemistry term used to describe an element's attractive force toward other elements. Carbon and oxygen both have high values and are attracted to each other to form new gases, such as carbon dioxide. Water vapor attaches to carbon by this force. The oxygen in the water binds with the activated carbon in the breather, thus preventing it from going any farther.

Most breathers also have a color-change indicator that shows when their useful life is up. This is accomplished with a water-reactive reagent embedded into the body of the silica. As water vapor attaches, it reacts inertly with the reagent, making it change its color.

Desiccant breathers generally have a synthetic fiber filter at the top to trap larger solid particles such as dust or organic material in the atmosphere. Next, there is a device called a diffuser, which takes incoming air and forces it through the entire volume of silica evenly. After the diffuser is the activated carbon, which serves to remove anything left after the initial filtration. As the container exhales, this process takes place in reverse, with the activated carbon absorbing the oil mist so as not to allow it back into the mass of oil after being in contact with other contaminants.

It is recommended that these breathers be installed in tandem with a vacuum gauge. In the case of dry environments, there may not be enough moisture ingression to cause a color change of the silica beads before the top layer of the synthetic filter is clogged with dust and other contaminants. A vacuum gauge will provide a visual signal as to when this occurs, since the air will not be able to pass through the entire breather.

As with most spin-on breathers, desiccant breathers often have a beta rating associated with them. This is a mark of how well the filter removes incoming contaminants.

Among the other criteria to keep in mind when selecting a filter is the cleanliness of the environment, which can affect its life expectancy. Obviously, the dirtier the air, the more particles the breather will trap. The amount of moisture or humidity in the air will determine how long you can go between filter changes.

The criticality of the machinery the breather is attached to is important to consider as well. If the machine operates on close tolerances with little room for particle ingression, you may need to get a high-quality breather and change it more regularly.

To maximize a breather's efficiency, ensure the headspace of the oil level is sealed tightly. The volume being protected should breathe only through the filter installed. A loose seal will defeat the purpose and allow a straight path for outside particles to enter the system.

Although breathers are relatively easy to install, the process of how they work is quite involved. Pairing science with real-world need provides the advantage required to tackle the challenges of particle ingression and maintaining the small fluid film on which this industry rides.

3 Key Properties of a Breather

Desiccant breathers can help control both moisture and dirt ingression. A good desiccant breather system is one that:

1) achieves the target level for cleanliness and dryness,
2) has the capacity to enable a sufficient service interval between change-outs,
3) is easily visible for routine inspection during preventive maintenance.

About the Author

Wes Cash is an associate technical consultant with Noria Corporation. He is a mechanical engineer who holds a Machinery Lubrication Technician (MLT) Level I certification through the International Council for Machinery Lubrication (ICML). Contact Wes at wcash@noria.com.

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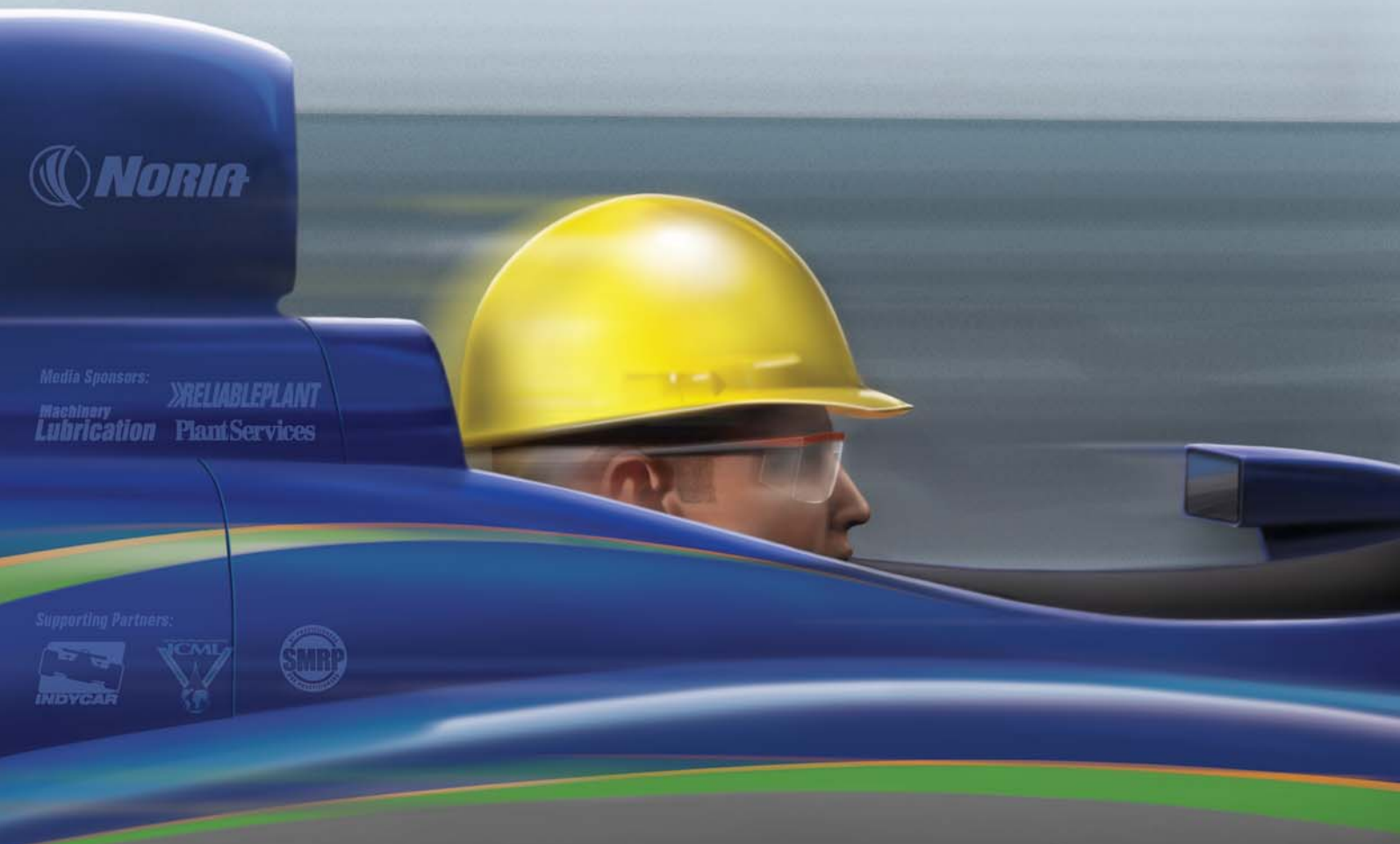

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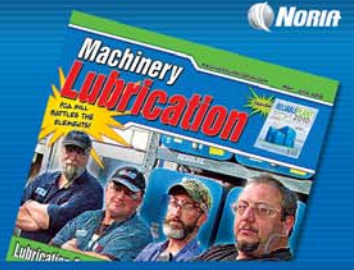

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